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A Test of Moral Quality

LIFE'S pathway is strewn with opportunities for every man to show how he values the amenities of existence and whether the ethics of his personal code are grounded in meanness and selfishness or upon the broad plane of human fellowship. A condition that gives especially wide scope for revealing generous traits of character, and one that is quite common in the experience of operating engineers, is present when circumstances invite a man to relinquish his job to a successor, whether the transfer be voluntary or otherwise.

Some engineers so situated seem to derive a great deal of satisfaction from leaving the new man puzzled by peculiarities incident to the plant, and with which they themselves have laboriously learned how to cope—particularly when inability to promptly understand such peculiarities embarrasses the newcomer and cheapens him in the estimation of his employer, who may not be qualified to justly appraise the situation.

Such want of generosity is perhaps born of the egotism inherent in some degree in all human character. The chief difference between the man of cynical and selfish qualities of mind and the man of generous impulse is that the latter tries to stifle the reprehensible elements of his nature while the former does not. An engineer of this churlish type, while shrewdly looking out that the condition of the plant shows nothing to reflect unfavorably upon his own skill and managerial ability, will often leave his successor to master the intricacies unaided in the secret hope that something will go amiss or that he himself will be called upon to adjust some troublesome detail for which the new man's previous experience supplies no solution.

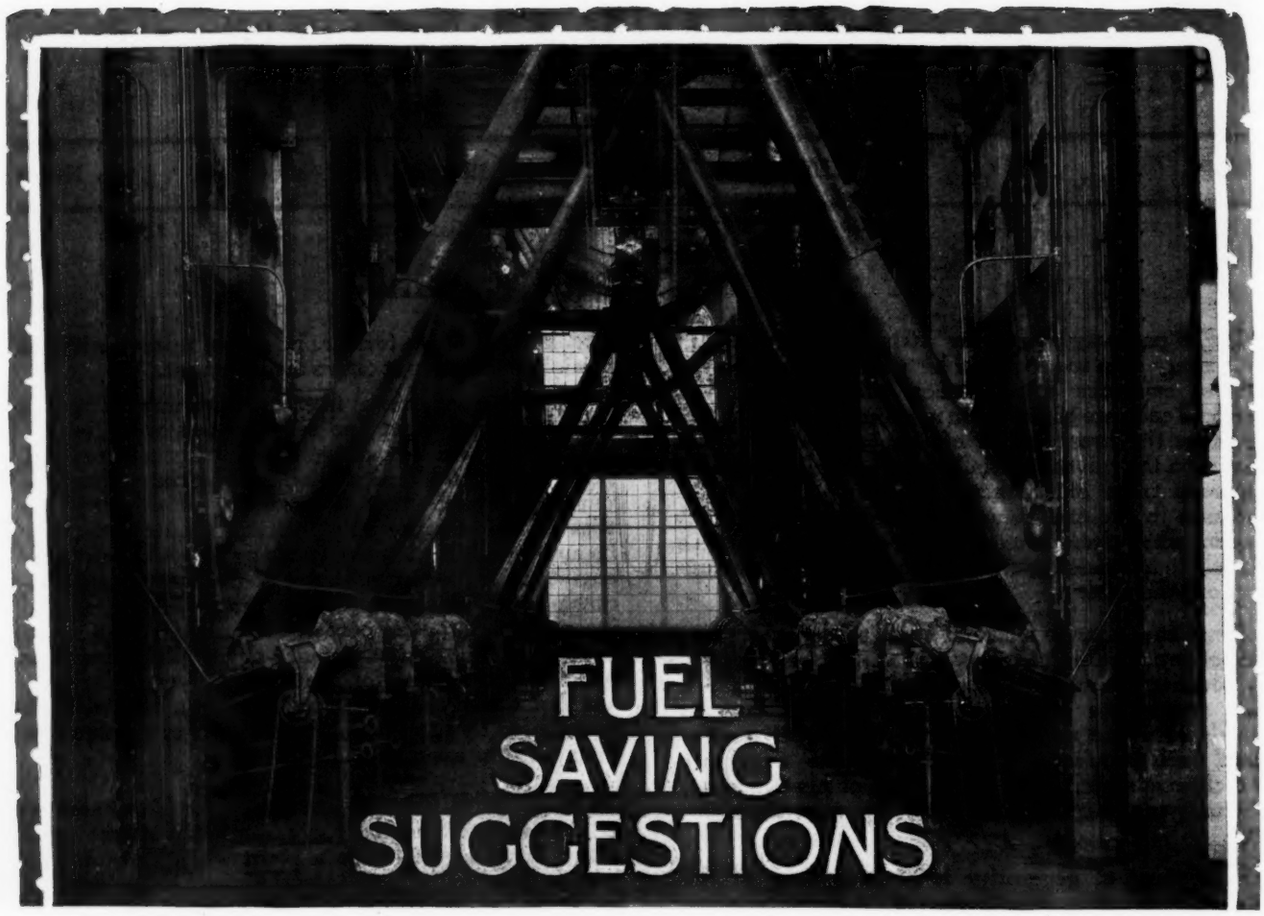
THEN again, an individual may occasionally be found so saturated with the sourness of an envious nature and so fearful that he will not be given undivided credit for every morsel of advantage that may have come to the plant under his management, even though a good deal of it may have originated in the brains of others, that he will deliberately let the equipment run down, if there is a chance of serious depreciation in the interval before his prospective successor assumes charge. He will try to square his meanness with the rules of right conduct by arguing that it gives the new occupant of the place a chance to prove his worth; he may even assert that it is not fair to either party concerned if the incoming engineer is left untrammeled to profit by the outgoing engineer's hard work, but that a just balance is struck when the former is given opportunity to straighten things out on his own account.

When a man's moral fiber becomes warped to this extent, his judgment and sense of proportion in conserving his own advantage likewise become twisted. His egotism and vanity blind him to the question of pure self-interest that is involved. He cannot see that in the end the only legitimate outcome of his meanness will be damage to his own reputation as an engineer. He seems oblivious of the fact that a run-down power plant serves to advertise real or alleged incompetency on the part of the engineer who left it so; that the mere circumstance of his having kept the plant in good shape for a number of years, perhaps, will not offset the unfavorable opinion that will be propagated by the new man's exposure of the flaws he finds when he assumes charge.

AN ENGINEER with any regard for his character as such cannot be too careful about the condition in which he leaves a plant when he quits the job. It behooves him to extend himself to the limit of his ability at such a time, if at no other, to see that no defect that can be rectified is left to reflect upon his skill and diligence.

But men who exhibit a character of unfriendliness in dealing with their fellows are exceptional among engineers of standing and ability. The moral natures of most good engineers are constructed of finer material and their mental perspectives follow a more logical trend. If innate generosity and a correct sense of right and wrong do not prompt the average engineer to treat his successor with exact fairness, then common sense will. He will give the new man the full benefit of his own experience in the plant, and will take extra pains to instruct him upon every detail that might harbor possible trouble for him, because he will recognize the advantage to himself of having the plant run without mishap for a time at least after he has relinquished charge of it, even if his attitude toward his successor springs from no loftier motive. He understands how readily an accident happening immediately subsequent to his departure from the plant could be attributed to alleged remissness on his own part, and how easily reports of conditions as found can be garbled and distorted to the lasting injury of an engineer's reputation. If the newcomer finds easy going at first, and events swing along smoothly for a month or two, it will be difficult for him to falsely charge delinquencies of his own to anything that might savor of neglect or ignorance on the part of his predecessor should he be inclined to do so later on.

Contributed by A. J. DIXON.



By CHARLES H. BROMLEY

The United States of America is the chief treasure chest, storehouse and workshop in the Democratic Allies' struggle for the right of civilization to keep its soul. The nation is a war machine. An engine, a lathe, an ingot, food and raw materials are as truly machines and munitions of war as cannon, shovel and shell.

THE war is not alone where men go "over the top." It is where you toil—and do your job efficiently or wastefully. The fuel situation of the world is indeed more serious than most of us know. Most of Europe is reported dark and cold. The streets are illuminated only enough to insure reasonable safety to traffic. Gas, and in many cities electricity for domestic consumption, is permitted to be used only between the hours of 5 and 11 p.m. The large public-utility companies are running on a hand-to-mouth supply, and many of the street railways have ceased to run. Industries engaged in the manufacture of commodities not vitally necessary to the war must wait for their coal until the industries important to the conflict are supplied.

The cry that there is no fuel shortage is false. True, the United States in 1916 did produce approximately 600,000,000 tons, as against 532,000,000 tons in 1915. But if one forgets that the world's consumption of coal is greater than it ever was, that the navies of the world are using fuel on an unprecedented scale, that the industries are not only working longer hours but at much faster rates, these figures become misleading. It is true that the railroads by curtailing passenger service have reduced their coal consumption by about 1,120,000 tons per year. But transportation facilities re more heavily taxed than ever before. The railroads n normal times have been using about 125,000,000 tons of coal per year. It is shown by the most accurate figures available that there has been an increase by the railroads, due to the war, of approximately 40,000,000 tons per year. The increased production of steel has caused an increase in bituminous-coal consumption of 40,000,000 tons in 1916. The extra demand for coal by the cotton industries of New England and the South has increased their coal consumption by at least 4,000,000 tons per year.

It is estimated that approximately 60 per cent. of the country's yearly output is consumed for steam making. Deducting the amount used by the railroads, 252,000,000 tons per year is used under stationary boilers.

The best boilers in the most carefully conducted plants do not get an average efficiency of over 70 per cent. Boilers maintained at 75 per cent. are indeed unusual; but they are capable of it. In the large plants where the equipment and skilled labor are the best, the daily average efficiency is seldom above 70 per cent.

Men who know will concede that 20 per cent. of the total yearly consumption by steam boilers is a conserva-

tive estimate of the avoidable waste. This amounts to 50,400,000 tons per year for stationary boilers. At $5 per ton the money loss is $252,000,000 per year—or as pointed out in the poster supplement to this article, enough to buy uniforms for more than three million "Sammies."

There is much discussion now as to the advisability of the Government compelling, under penalty of withholding the supply, efficient use of the coal in steam boilers. There is no good reason why the Government should not do this, although it is not desirable; and further, output is what is needed, and to stop the supply of coal is to stop the output. The Governments, both state and Federal, require that the public-utilities corporations shall operate efficiently, and in the minds of many competent to judge, it is not long before they will hold private corporations to the same requirements. The Fuel Administration does not ask you what you are going to do about it. It tells you that you must save.

The following discusses some of the sources of appreciable loss and how the waste may be minimized. Two of the greatest sources of waste are due to the admis-

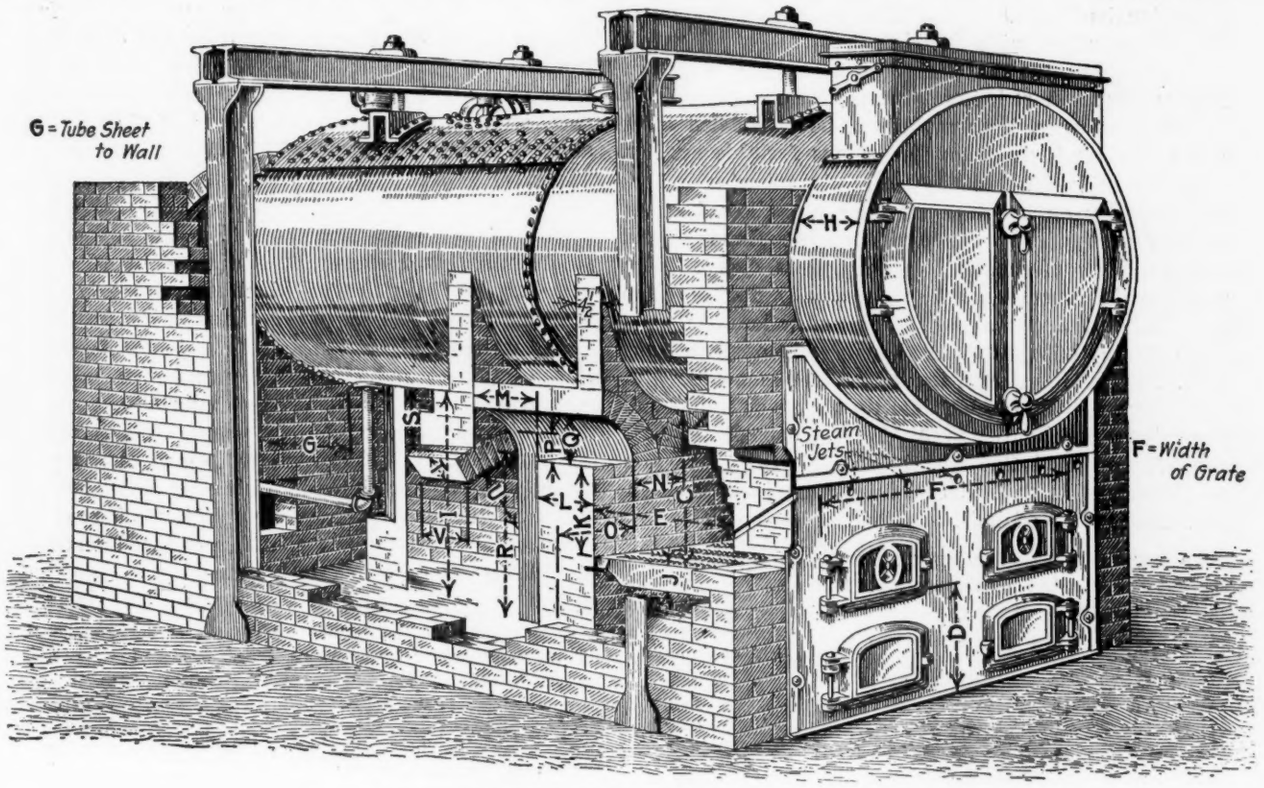


FIG. 1. EXCELLENT TYPE OF BOILER SETTING FOR SOFT COAL
(Reprinted from "Power" of Jan. 9, 1917)

TABLE 1. SPECIFICATIONS FOR IMPROVED SETTING HORIZONTAL TUBULAR BOILERS TO ACCOMPANY FIG. 1

Diameter shell	84 in.	84 in.	78 in.	78. in.	72 in.	72 in.	66 in.	66 in.	60 in.	60 in.	54 in.	54 in.
Length shell	20 ft.	18 ft.	20 ft.	18 ft.	18 ft.	16 ft.	18 ft.	16 ft.	18 ft.	16 ft.	16 ft.	14 ft.
C	42 in.	42 in.	42 in.	42 in.	36 in.	36 in.	36 in.	36 in.	36 in.	36 in.	36 in.	36 in.
D	2 ft. 2 in.	2 ft. 2 in.	2 ft. 2 in.	2 ft. 2 in.	2 ft.	2 ft.	2 ft.	2 ft.	1 ft. 10 in.	1 ft. 10 in.	1 ft. 10 in.	1 ft. 10 in.
E	6 ft. 6 in.	6 ft.	6 ft. 6 in.	6 ft.	6 ft.	5 ft. 6 in.	5 ft. 6 in.	5 ft.	5 ft. 6 in.	5 ft.	4 ft. 6 in.	4 ft.
F	7 ft.	7 ft.	6 ft. 6 in.	6 ft. 6 in.	6 ft.	6 ft.	5 ft. 6 in.	5 ft. 6 in.	5 ft.	5 ft.	4 ft. 6 in.	4 ft. 6 in
G	2 ft. 10 in.	2 ft. 10 in.	2 ft. 8 in.	2 ft. 8 in.	2 ft. 6 in.	2 ft. 6 in.	2 ft. 4 in.	2 ft. 4 in.	2 ft. 2 in.	2 ft. 2 in.	2 ft.	2 ft.
H	1 ft. 10 in.	1 ft. 10 in.	1 ft. 9 in.	1 ft. 9 in.	1 ft. 8 in.	1 ft. 8 in.	1 ft. 7 in.	1 ft. 7 in.	1 ft. 6 in.	1 ft. 6 in.	1 ft. 5 in.	1 ft. 5 in.
I	6 ft. 4 in	5 ft. 10½ in.	6 ft. 5½ in.	6 ft.	5 ft. 11½ in.	5 ft. 6½ in.	5 ft. 7 in.	5 ft. 1½ in.	5 ft. 9 in.	5 ft. 4 in.	4 ft. 11 in.	4 ft. 8 in.
J	6½ in.	6 in.	6½ in.	6 in.	6 in.	5½ in.	5½ in.	5 in.	5½ in.	5 in.	4½ in.	4 in.
K	1 ft. 10½ in.	2 ft.	1 ft. 9½ in.	1 ft. 11 in.	1 ft. 6 in.	1 ft. 7 in.	1 ft. 7 in.	1 ft. 8 in.	1 ft. 5½ in.	1 ft. 6½ in.	1 ft. 7½ in.	1 ft. 6 in.
L	2 ft. 3 in.	2 ft. 3 in.	2 ft. 3 in.	2 ft. 3 in.	2 ft.	2 ft.	1 ft. 10½ in.	1 ft. 10½ in.	1 ft. 10½ in.	1 ft. 10½ in.	1 ft. 6 in.	1 ft. 6 in.
M	3 ft.	3 ft.	2 ft. 10 in.	2 ft. 10 in.	2 ft. 6 in.	2 ft. 6 in.	2 ft. 4 in.	2 ft. 4 in.	2 ft. 2 in.	2 ft. 2 in.	2 ft.	2 ft.
N	1 ft. 6 in.	1 ft. 6 in.	1 ft. 6 in.	1 ft. 6 in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.
O	2 ft. 9 in.	2 ft. 9 in.	2 ft. 6 in.	2 ft. 6 in.	2 ft. 5½ in.	2 ft. 5½ in.	2 ft. 2½ in.	2 ft. 2½ in.	1 ft. 11½ in.	1 ft. 11½ in.	1 ft. 8½ in.	1 ft. 8½ in.
P	1 ft. 4 in	1 ft. 2 in.	1 ft. 5½ in.	1 ft. 3½ in.	1 ft. 1 in.	1 ft. 1½ in.	1 ft. 1½ in.	1 in.	1 ft. 3 in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 2½ in.
Q	2 ft. 5½ in.	2 ft. 3½ in.	2 ft. 5½ in.	2 ft. 3½ in.	2 ft. 2 in.	2 ft. ½ in.	2 ft. ½ in.	1 ft. 11 in.	2 ft. ½ in.	1 ft. 11 in.	1 ft. 8½ in.	1 ft. 9 in.
R	4 ft. 2 in.	3 ft. 10½ in.	4 ft. 2½ in.	3 ft. 11 in.	3 ft. 11½ in.	3 ft. 8 in.	3 ft. 8½ in.	3 ft. 4½ in.	3 ft. 9 in.	3 ft. 5½ in.	3 ft. 2 in.	2 ft. 10 in.
S	2 ft. 2 in.	2 ft.	2 ft. 3 in.	2 ft. 1 in.	2 ft.	1 ft. 10½ in.	1 ft. 10½ in.	1 ft. 9 in.	2 ft.	1 ft. 10½ in.	1 ft. 9 in.	1 ft. 10 in.
T	9 in.	9 in.	9 in.	9 in.	9 in.	9 in.	9 in.	9 in.	9 in.	9 in.	9 in.	9 in.
U	1 ft.	1 ft.	1 ft.	1 ft.	1 ft.	1 ft.	11 in.	11 in.	10 in.	10 in.	9 in.	9 in.
V	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.	1 ft. 1½ in.
Number and size of tubes	92–4 in.	92–4 in.	88–4 in.	88–4 in.	70–4 in.	70–4 in.	54–4 in.	54–4 in.	46–4 in.	46–4 in.	36–4 in.	36–4 in.
Heating surface in tubes	1932.0	1738.8	1842.8	1658.5	1323.0	1176.0	1017.7	904.6	866.9	770.6	604.8	529.2
Heating surface in shell	219.9	197.9	204.2	183.8	169.6	150.7	155.5	138.2	141.3	125.6	113.1	99.0
Total heating surface tubes and shell, sq.ft	2151.9	1936.7	2047.0	1842.8	1492.6	1326.7	1173.2	1042.9	1008.2	896.2	717.9	628.2
Boiler horsepower	215	194	205	184	149	133	117	104	101	90	72	63
Square feet of grate surface	45.5	42.0	42.25	39.0	36.0	33.0	30.25	27.5	27.5	25.0	20.25	18.0
Area through each bridge wall retort, sq.in	820.0	756.0	761.0	702.0	648.0	594.0	544.5	495.0	495.0	450.0	364.5	324.0
Area between bridge wall and deflection arch, sq.in	2448.0	2448.0	2040.0	2040.0	1770.0	1770.0	1484.0	1484.0	1326.0	1326.0	984.0	984.0
Area under deflection arch	3280.0	3024.0	3041.0	2808.0	2592.0	2376.0	2177.0	1979.0	1979.0	1800.0	1457.0	1296.0
Area of tubes, sq.in	1011.0	1011.0	967.0	967.0	769.0	769.0	593.0	593.0	505.0	505.0	396.0	396.0
25 per cent. over flue area	1264.0	1264.0	1208.0	1208.0	961.0	961.0	741.0	741.0	631.0	631.0	495.0	495.0

Notes—First grade of firebrick to be used throughout with the exception of the combustion chamber floor and the side walls of the chamber back from a point one foot behind the rear face of the deflection arch. Fire-doors MUST provide for special air admission of an area equal to 4 sq.in. for each square foot of grate surface, when working pressure on boiler is 20 pounds or less. If desired, these doors may be used on boilers carrying more than 20 pounds pressure. Make the effective area through damper frame not less than the combined area of tubes. See ordinance for breeching and other regulations. Table applies only for the ordinary conditions and is subject to revision or modification for unusual conditions. Heating surfaces are in square feet, areas in square inches, except for grate surface.

sion to the furnaces of great quantities of excess air and to the loss of heat up the stack. The short, simple instructions in the supplement to this article will, if followed out, assist appreciably in cutting down the waste of a product vital to the conduct of the war.

In plants where the coal will run above, say, 20 per cent. volatile, it becomes necessary, for economy, to have a furnace suitable for its combustion. The furnace shown in Fig. 1 has been found to give excellent results all through the Middle West. The City of Cincinnati's Smoke Inspection Department specifies it. Although not extensively used in the Pittsburgh district or in districts supplied with Pittsburgh and West Virginia coal, it is advisable that this design be adopted in new installations. Where boiler settings are to be extensively repaired any way, they could well be remodeled after Fig. 1. Table I gives the dimensions for this setting.

On account of the loss that occurs by allowing boilers to loaf along on the line, as they are allowed to do in many of the industries during nights, Sundays and holidays, it is advisable that all boilers except those necessary to carry the load economically during these times be banked. In Table II is shown the loss of money over a period of a year occasioned by incomplete combustion or by the formation of carbon monoxide and the passing of this combustible up the stack unburned. This table was prepared by A. V. King, consulting engineer, Consolidated Gas Co., New York City, and for the Brooklyn Union Gas Co., Brooklyn; it is used in the boiler rooms of both companies.

TABLE II. LOSS PER 1,000 TONS COAL DUE TO EXCESS AIR

(Based on flue gases escaping at 500 deg. F.)

CO_2 per Cent.	Loss Figured from Attainable CO_2 per Cent.	Unnecessary Excess Air, per Cent.	Loss on 1,000 Tons Coal at $3.00 per Ton	Color of Fire	Approximate Corresponding Temperature, Deg. F.
14	0	00	.....	Bright white	2,600
13	1	11	$30.00	White	2,200
12	2	20	60.00	.....	.....
11	3	40	90.00	.....	.....
10	5	60	150.00	.....	.....
9	7	82	210.00	Light orange	1,750
8	10	112	300.00	.....	.....
7	13	148	390.00	Bright cherry	1,400
6	17	197	510.00	.....	.....
5	23	266	690.00	Dull cherry	1,150
4	32	370	961.00	.....	.....
3	47	442	1,411.00	Dull red	1,000
2	77	885	2,310.00	Dark red	900

The loss of combustible through the grate with the ash is the cause of an appreciable percentage of the yearly waste. Not all of this, of course, is avoidable; but it may be kept down if constantly watched as it is, for instance, in the Delray station of the Detroit Edison Co., Detroit, Mich., where the ash is analyzed daily and its carbon content posted in the boiler room so that the firemen may know from day to day how efficiently they are performing their work. The magnitude of this waste may be appreciated if we take 300,000,000 tons as the amount of coal burned under steam boilers per year in the United States and consider 10 per cent. of this as ash; this gives 30,000,000 tons of ash. If 20 per cent. of the ash is combustible, 6,000,000 tons of combustible (not coal) is the magnitude of the waste. Back in 1913 estimates show that in Germany at least 4,000,000 tons of coal was the loss per year due to combustible going through the grate. At that time a movement was on foot to recover a part of this waste by placing the coal-bearing ash in a liquid having a specific gravity greater than the coal but less than the ash. In a trial the apparatus is reported to have removed 800 tons of coked coal from 2000 tons of ashpit refuse. Of this, 500 tons was in pieces from 1¼ to 2 in. in size, while the rest was suitable for briquetting.

Unless it is necessary to get capacity, most stokers, especially those of the underfeed type capable of high combustion rates, should not be run above 200 to 250 per cent. normal rating of the boiler. At these high combustion rates with few exceptions, perhaps, coal is fed to the stokers so rapidly that, with present provisions for air admission to the lower part of the furnace and means of breaking or agitating the clinker to allow air to get to it so as to burn out the carbon without overbalancing the gain with excess air admission, it is wise to run more boilers, if they are available, at lower rating. It will be found that doing this will give a much higher boiler efficiency, as boilers operate at their best efficiency a little below rather than a little above their normal rated capacity. To accomplish this, however, it would not be wise to put into service those boilers which are properly held in reserve. Local conditions must govern the operator.

The writer will not attempt to state the losses occasioned by soot and clinker on the boiler tubes; but certain it is that these help very materially to cut down the heat-transmission rate, and proportionately increase the heat loss. It is the practice of many plants to blow the boilers out once a week, either on Saturday afternoons or Sundays. This is done at these times chiefly because the load on the plant is reduced sufficiently so that the soot, which is blown down onto the fire, will not cause a shortage of steam and a lowering of the pressure by deadening the fire. It is suggested that where conditions permit, at least some of the boilers be blown more often. This is desirable for two reasons: It will keep the mean average heat-transmission rate higher throughout the week and will not blanket the fire objectionably heavily at one time.

The time has come when every engineer ought to know how to use an Orsat and how to interpret what it tells. This brings up the question of air leakage through the boiler settings. For the large cracks in the settings the writer finds that old waste soaked in a mixture of fireclay and water makes an excellent filling. The crack should be smoothed over at the surface with fire cement, or portland cement, if on the outside wall.

It is, of course, impossible to estimate the waste occasioned by building new fires in boilers and cutting boilers in on the line when this becomes necessary, owing to carelessness or mismanagement—that unnecessarily causes accidents to boilers that require them to be taken off the line. It is doubtful if the average boiler can be fired up and put in on the line for less than $25.

With the wide use of the water-tube boiler, where baffles are used, it is most important to maintain the baffles so that they are tight and that the gases do not short-circuit and take a direct path to the uptake instead of being swept over the heating surface. Analyses of the gases in the different passes of the boiler and observation of the uptake temperature will reveal broken baffles.

Starting the Fire: Cover the grate with coal, small

lumps if available, to a depth of 3 in. Now put on a layer of shavings or small wood. Throw on kerosene- or crude oil-soaked waste to ignite the wood or shavings front and back. Put on the draft, natural or blower, and leave the fire-door open a little. Try to get the coal on the grate burning before throwing on fresh coal. Close the door when the coal becomes well ignited.

Maintaining the Fire: Use the slice bar only when absolutely necessary. Don't turn the fire over; but keep the large clinker broken. Cover the fire only where it burns out; this will avoid holes in the fire and losses due to excess air. Don't cover all the fire at one time. Don't carry the fire more than 12 in. thick, if avoidable. Leave the fire-doors open for awhile after coaling up or put on the blower that blows air and steam in above the fire until the heavy volatiles are driven off, if the boiler has such a blower.

Cleaning the Fire: Have enough water in the boiler to permit of shutting off the feed when ready to clean. Have a good fire before starting to clean. Pull the live coals from the backs of the grate on to the fire at the front half. "Jump" the ash and clinker forward over the live coal and out the fire-door. Cover the bare grate with fresh coal to a depth of a few inches. Push all the live coal back on the fresh or green coal. Pull out the ash and clinker on the front half of the grate, after which cover it with green coal as you did the back half. Pull enough live coal forward to get the fire level on the whole grate. Turn on the feed water as much as necessary.

All of the losses are not in the production of the steam. The heating season is here. It is not uncommon to find live steam turned into the heating system and the back-pressure valve closing the system to the atmosphere bobbing up and down off its seat, permitting much of the steam in the system to go to the atmosphere instead of performing the intended service. The thing to remember is that every pound of this exhaust steam represents in round numbers a thousand B.t.u.'s, and much more than this in terms of coal.

Where the heating system is large and the exhaust steam must be carried considerable distances, a serious mistake is made by not running live-steam lines direct to these remote parts of the system and, when the exhaust-steam supply is inadequate, admitting the live steam to the system at these points, where it is not only needed but where the steam used for heating will be used most efficiently. To do good, the steam must give up its heat at the point where the heat is wanted. Where live-steam connections are not provided at the extreme ends of the system, and where the live-steam connection is direct from the boiler into the heating main at the center or other extreme end of the system, the live steam admitted to the main gives up most of its heat before reaching the remote parts of the system. In other words, the steam does not give up its latent heat in the radiators, at the points where the heat is wanted.

Care should be taken that condensate does not find its way to the sewer, provided it can be utilized. It is surprising what the high coal prices have done, in many New England plants particularly, to prevent the waste of heat to the sewers and atmosphere by reclaiming the condensed steam by the use of traps.

Now is indeed an opportune time to impress employers with the fact that investment in coal scales, thermometers, Orsats, draft gages and water meters will bring large and quick returns. With these the engineer can make good use of the daily record of the coal and water consumption.

Conservation by new or improved equipment is limited almost exclusively to extensions of present plants. Factories and mills can likely profitably make use of the bleeder-type turbine more extensively than they have heretofore. The heat return to the plant per unit amount of heat expended is, where this turbine is suitable, considerably more than with the straight condensing turbine.

For extensions to refrigerating plants, the high-speed compressor is admirably adapted.

The engineer must also conserve ammonia as well as coal, oil and steam. The consumption of the raw materials from which ammonia is made has been greatly increased, owing to their use for other purposes, and together with the requirements of ammonia in the Government refrigerating and munition plants, makes it imperative that leaks in ammonia refrigeration systems be stopped. When purging the condensers, also when blowing out oil traps, do not continue the blowing long enough to waste the ammonia. Leaks in the cooling coils must be guarded against, and for this purpose, Nessellers solution or reagent, as it is often called, may be used.

There are many organizations of professional and operating engineers, among which are men whose services the Fuel Administration could well enlist for the purpose of going before the engineers' and firemens' organizations and lecturing to them on how to save fuel.

The following publications are recommended: Bureau of Mines, Washington, D. C.: "Hand-Firing Soft Coal Under Power Plant Boiler," Technical Paper No. 80; "Sampling and Analyzing Flue Gases," Bulletin No. 97. University of Illinois, Urbana, Ill.: "How to Burn Illinois Coal without Smoke," Bulletin No. 7.

To Distinguish Wrought-Iron from Steel Pipe

In the process of steel manufacture, manganese has to be added to the molten metal in order to make it possible to roll and weld it into pipe, while wrought iron requires no such manganese addition and therefore usually contains only a trace of this metal. To test for manganese place in a porcelain dish, preferably a small porcelain crucible, a clean, bright drill chip or some filings of the metal to be tested, about the size of a pinhead; add six drops of pure nitric acid, heat, add two drops of silver nitrate solution, then one crystal of ammonium persulphate not greater than one-eighth inch in diameter. Warm the solution, but do not let it boil. If the metal is steel, a pink color will begin to develop and at this point it should be removed from the source of heat, when a very decided red coloration will result. If no coloration develops, but a small amount of dark residue remains in the dish, the metal is wrought iron.

Care should be taken at all times to test only clean samples and to keep dirt or foreign matter out of the dish. If a thimble-size crucible is used, a match will supply sufficient heat for the purpose—*Thomas F. Payne.*

Features of Automatic Hydro-Electric Plant*

Rise of water level causes proper number of generators to start to utilize water most economically—simplicity of construction and arrangements for supervisory control in emergencies.

A HYDRO-ELECTRIC generating station which is automatic in all of its operations has recently been placed in service by the Iowa Railway and Light Co., on the Cedar River, only a few blocks from the business district of Cedar Rapids. The plant, which will have an ultimate capacity of 2000 kw., operates in parallel with an extensive transmission system which already reaches practically across the State of Iowa, except for a 28-mile break near Marshalltown. There are no instruments in the hydro-electric plant, these being installed in the company's steam station, which is about 0.6 mile distant. Three groups of conductors—power cables, instrument cables and control cables—connect the two plants; hence, while the hydro-electric station is self-controlled, and automatic,

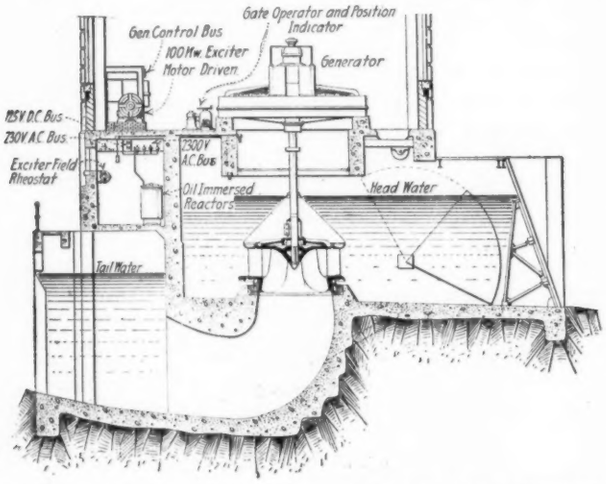


FIG. 1. USE OF TAINTER GATE AND POSITION OF BUSSES WITH RESPECT TO CONTROL CABINETS

it is possible for the steam-plant operators to control the action of the waterwheels and generators.

Perhaps the most spectacular and surprising feature of the whole plant is the speed with which the station goes into service. It requires just 37 seconds from the time the first switch operates until the first generator is under full load. A somewhat formidable array of mechanism might be expected in a plant of this nature, but the contactors and switches are inclosed in cabinets and the busses and control wires are run through bus chambers beneath the floor, so that the interior of the station appears very simple. With this arrangement, and by making each generator and its circuits, except for excitation, an independent

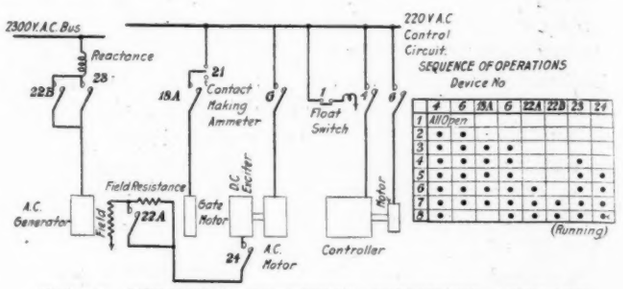


FIG. 2. SEQUENCE IN WHICH SWITCHES OPERATE

unit, every element of the wiring and control apparatus has been made readily accessible.

The excitation for each machine is maintained at a fixed value at all times, thus simplifying the excitation problem, eliminating the necessity of voltage regulators, making it possible to take advantage of the full capacity of the river, and at the same time improving the power factor of the system through the operation of underloaded, overexcited machines. No oil governors are used for any of the machines, the gates being operated by motors which are under automatic control at the hydro-electric station, or remotely controlled from the steam station.

In general, the operation of the plant may be managed in either one of two ways. In either case the plant operates automatically, but in one case the control is vested in float switches and contact-making ammeters in the hydro-electric plant; in the other case it is vested in remote-control switches on the benchboard at the steam-power house. With the plant under the control of the float switches, the generators are automatically started as the head of the dam rises above certain definite levels owing to the increasing supply of water and the rising of the automatic flashboards. Likewise, the machines are automatically stopped if the head is lowered. With this system as many machines will come into operation and remain in operation as the supply of water justifies. Through the control on the benchboard at the plant, however, it is possible to start any or all of the machines at any time and to control the gate opening and load on any machine at any time.

*From the "Electrical World," Dec. 1, 1917.

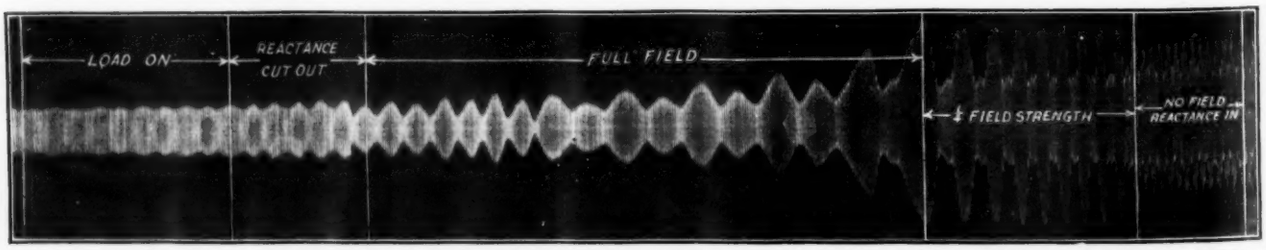


FIG. 3. OSCILLOGRAM OF GENERATOR CURRENT DURING STARTING PERIOD (PEAK VALUE OF CURRENT IS 234 AMP.)

As a rule, the latter plan of operation will probably be followed, running as many machines during the daytime as it is possible to operate and still permit the river to store up water for use at night. Then during the night the entire hydro-electric plant will be in operation under the control of the operators at the steam plant. This method of operation has been

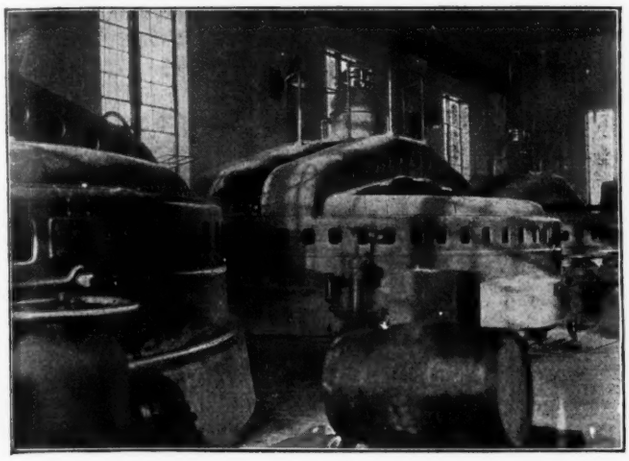


FIG. 4. THREE GENERATORS IN IOWA AUTOMATIC HYDRO-ELECTRIC STATION

selected as that which fits in best with the conditions on the system. With all three machines at the hydro-electric station operating, one boiler at the steam station may be shut down at night.

The hydro-electric plant is a particularly valuable adjunct as a safeguard against interruption to service. For instance, if one of the large turbine units in the power house loses its vacuum, it will be possible for the operators there to place 1500 kw. of hydro-electric capacity on the line in less than a minute by the operation of three buttons on the benchboard. Moreover, the operator who pushes these buttons need not stand at the benchboard and wait for the hydro-electric plant to come to the line, but can immediately leave the benchboard for the vacuum pumps and assist in getting the steam turbine back on the line promptly.

Another unusual operating plan is made possible by the fact that the excitation furnished to the hydro-electric machines is of a constant quantity. For example, in case there is enough water flowing in the river to permit the operation of one machine at full load and to produce 100 kw. on another, full use can be made of the water and of the windings on the second machine by taking the control away from the contact-making ammeter and using the underloaded hydro-electric machine to absorb a large part of the wattless component of the system load. This, of course, will greatly help the power factor of the system.

The Hydraulic Equipment

The normal head at the plant is 10 ft., but the head may vary from 8 to 11 ft. Records that have been taken to ascertain the characteristics of the river show that during 180 days out of 365 the average discharge is about 2100 cu.ft. per sec. The lowest flow per day is 500 cu.ft. per sec. This low-water period lasts for about four days in the year. The maximum flowage of the river is 50,000 cu.ft. per sec., about twelve or fourteen days in the year being flood days. These flowage data should be considered in connection with the fact that each runner in the plant takes 720 cu.ft. of water per second, three 500-kw. units now being in service.

The dam is composed of nine 60-ft. spillway sections, each of which automatically rises and falls with the flowage of the river, giving an automatic flashboard effect. Four motor-driven Tainter gates are installed at the intake to the flume. The wheel pits at the power house are independent of each other, and are equipped with 20-ft. Tainter gates on the upstream side and stop logs on the downstream side. This makes inspection easy, and did not complicate the layout, or cost much more. The waterwheels, which are of the Francis single-runner type, measure 171 in. in diameter and are rated at 540 b.hp., 60 r.p.m., and 84 per cent. efficiency under a 10-ft. head. This type of wheel was chosen since they must necessarily operate at low speed and since it was desirable to install direct-connected units. The thrust bearings on the machines are of the plate type, which is a modified Kingsbury bearing. The oiling system is driven by a direct-connected pump. The oil will need replenishing about four times a year.

The generators are two-phase 60-cycle 60-r.p.m. 2200-volt 109-amp. (per phase) vertical machines, and are arranged in a single row. Two-phase units were selected because the company's large steam plant still operates two-phase. There would be little difference between this hydro-electric station as a two-phase or a three-phase plant, however, since a four-wire system would be used in either case. Two induction, motor-driven, compound-wound interpole exciters, each capable of exciting the ultimate equipment in the plant, are installed.

The control cable, which consists of 52 No. 12 rubber-covered wires in a lead sheath between the hydraulic

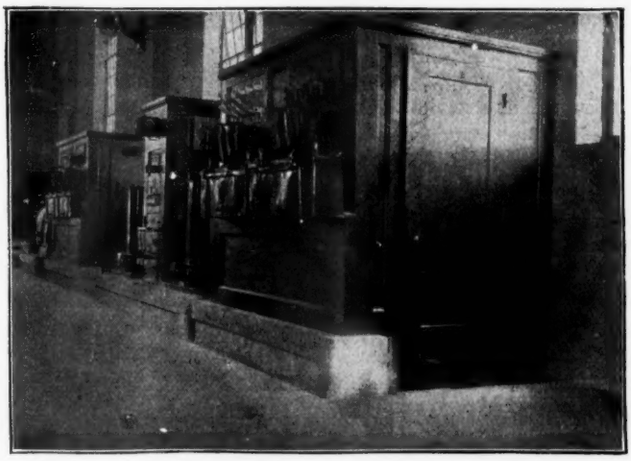


FIG. 5. GENERAL VIEW OF CONTROL CABINETS WITH CONTROLLERS BETWEEN

and steam plant, was not combined with the instrument cable, as breakdown in one of the current transformers might apply a high potential to the control circuits. Of the 52 wires in the control cable, 38 are used for indicating the gate positions. All cables between the plants, some 3300 ft., were laid underground to guard against lightning.

The control equipment at the hydro-electric plant consists of standard control apparatus, much of which is of the so-called steel-mill type. This type of equipment was selected because it is rugged and is not too sensitive. Hence, while the plant itself is something entirely new in the field of hydro-electric development, its greatest feature, the automatic control, consists of an assembly of standard equipment arranged to perform special duties. The control equipment is assembled on three generator-control cabinets and one exciter-

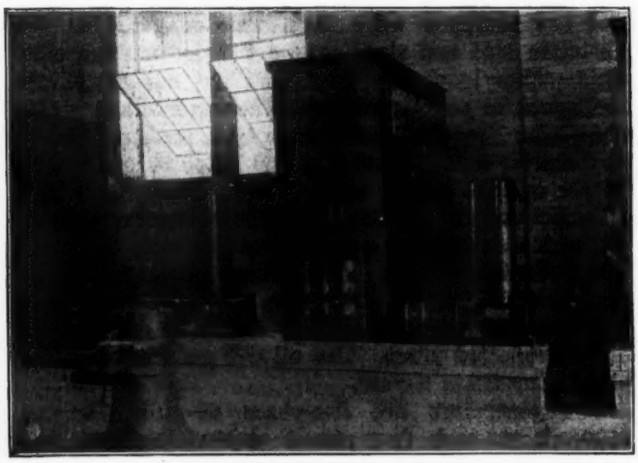


FIG. 6. AUTOMATIC CONTROLLERS AND EXCITER CABINET WITH FREQUENCY-LIMITING DEVICE AT TOP

control cabinet, a fourth cabinet serving as a terminus for all control and instrument wires. The instrument wires and transformers are so arranged that it is possible to "cut in" portable instruments, this being considered advisable since there are no permanent instruments at the hydro-electric plant. In addition to the equipment mounted on the cabinet boards, there are three motor-driven drum controllers which control the sequence of operation of the remaining control equipment, thus preventing mistakes.

Starting with the station at rest, the only live parts in the plant are the controlled transformers and the induction-motor speed-limiting device. To begin with, buttons Nos. 1, 2 and 3 on the benchboard in the steam plant, which are normally open, are closed. The drum controller then starts to run. The action to this point could also be accomplished by the action of automatic float switches if the plant were being operated on that plan. The first function the drum performs is to start one of the exciter sets. The 150-hp. motor of this set is thrown directly across a 2300-volt line. It comes up to full speed and full voltage in 3.5 seconds. The motor, in starting, takes eight times full-load current momentarily. The drum continues to run, and closes the necessary contact to drive the gate motor, which opens the gates on the waterwheels to about two-tenths full opening. The control circuit is then deënergized and the drum stops until the generator reaches a speed of 55 r.p.m. At this time a centrifugal speed switch on the top of the generator shaft makes a contact which closes other contacts to start the drum again.

The functions next performed by the drum are: First, the main-line contactor is closed, putting the machine in on the line without excitation, and in series with a set of reactors which limit the generator current to about 2½ times full-load current during the synchronizing period. Two of these reactors, which are of the single-phase oil-immersed type and are designed for five-minute duty, are installed with each machine. The time element between the closing of the speed switch on the main generator and the closing of the main-line contactor is of such an interval as to permit the generator speed to increase from 55 r.p.m. to 60 r.p.m., or synchronous speed, before the main-line contactor closes. The next function performed by the drum is to close the field contactor, the field rheostat being divided into two sections, so that when the field is connected with the line the current is only approximately one-fourth its normal value. Next, the drum closes the contactor, which shunts out a section of the field rheostat, increasing the field current to its normal value. Then current-limiting reactors are short-circuited, and the contact-making ammeter closes a circuit actuating the gate motor, which opens the gate to a point that will permit the machine to carry a predetermined load.

Since the station is to be left attendantless except for one visit every eight hours by an employee just off shift at the steam plant, it must take care of its own cases of trouble, if any arise. To that end the machines are protected against hot bearings by thermostats of the spiral-spring type installed on each bearing. These thermostats are set to operate at 45 deg. C. In common with all other thermostatic control in the station, these bearing units operate to shut down the machine affected entirely and keep it shut down until conditions again become normal, when the machine will start of its own accord. Thermostats are also placed on the current-limiting reactors and are set to operate at 75 deg. C. Thermostats on the stator coils of the generators are set to operate at 65 deg. C. The speed-limiting

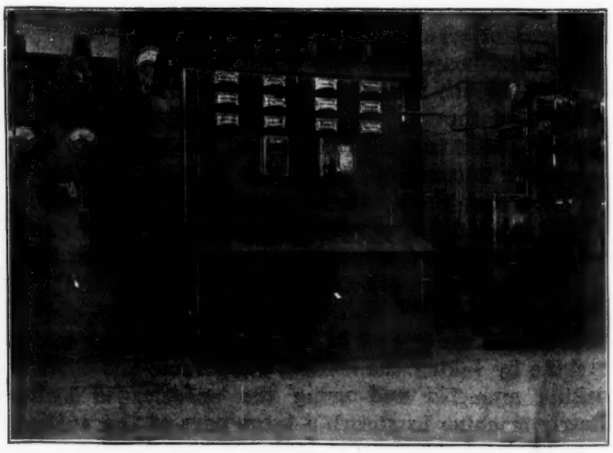


FIG. 7. BENCHBOARD AT STEAM STATION FROM WHICH AUTOMATIC HYDRO-ELECTRIC PLANT MAY BE SUPERVISED

device consists of a 1-hp. induction motor running light, with a centrifugal switch attached to the end of its shaft. When the frequency of the station reaches 64 cycles the centrifugal switch operates to shut down the plant. To test out this device the main oil switch at the steam station was tripped from the benchboard, cutting all load off the hydro-electric plant, which, of course, would tend to make it run

away. In 1.4 seconds after the oil switch was stripped, the frequency-limiting device had operated and the waterwheel gates were beginning to close.

Single-Phase Operation

Single-phase operation is prevented by the fact that a part of the relays are in one phase and a part in the other, and the wiring is laid out so that any one of the relays opening will open all contacts and shut down the machine. Of course, no voltage failures on alternating current are guarded against, since under these conditions there would be no energy to hold in any of the contactors. The loss of excitation is guarded against by a relay in series with contacts which in opening shut down the plant. The machines are protected against surges by a time element in the setting of the relays, which under abnormal conditions cuts the reactors into circuit for an interval before the machine goes off the line. Ordinarily, two 5-kv.-a. transformers furnish energy for the control. In case of an emergency, however, a throw-over switch connects the steam station power and lighting transformers with the control circuit.

The float switches guard against trouble from low water. No special provision has been made to guard against frazil ice, and the only precaution taken in guarding the water supply are standard trash racks at the intake to the wheel pit and at the intake to the flume. It is interesting to observe in this connection that a sudden stoppage of all units in the plant produces a water-hammer effect in the flume, piling this water up at the gates to such an extent that the back wash effectively clears all trash from the racks and causes material which has gathered at the upstream trash rack to be washed over the spillways.

Forty-Eight Trouble Conditions

Since the plant has been in operation, the engineers of the central-station company and of the manufacturing company conceived 48 conditions and combinations of conditions which might occur to cause trouble at the plant. Each one of these conditions was brought about artificially, and the result in each case was the automatic shutting down of the plant until normal conditions were restored. In these tests everything from dead short-circuits to exciter failures was tried out.

One of the striking things about the design and construction of this station was that relatively few changes were necessary in the original layout in order to make the plant operate as planned. The changes consisted of the addition of four relays. One relay was added to short-circuit the exciter-field rheostat to make the exciter set come up to voltage as fast as it came up to speed. This provision was thought wise in that the failure of the exciter to come up to voltage rapidly might necessitate making the control drum revolve twice before the generator could be put on the line. Relays were also placed so that shutting down or starting up of any one of the generators would stop or start an exciter set. The addition of these relays makes it possible to shut the machines down in any sequence or to start them up in any sequence, the first machine started up always starting the exciter set and the last machine shut down always shutting down the exciter set.

The preliminary work on this water power was being done at about the time Taylor and Allen were working on the automatic rotary converter substation at Union, Ill. (See "Proceedings A. I. E. E.," Vol. 34, Part 2, p. 1801.) The original idea at Cedar Rapids was to install a station with remote control and operate it from the steam plant very much in the way that the so-called automatic substations at Detroit are operated. Such an arrangement was finally considered inadvisable, as it involved many complications and provided too great an opportunity for an operator to make mistakes. It was believed that by installing an automatic plant there was an opportunity to effect a saving of some $3600 to $4000 a year in labor. Owing to the fact that apparatus already standardized has been used exclusively, and to a rather liberal policy of the manufacturer in absorbing such development charges as were necessary in working up the layout, the actual investment in this plant is no greater than would have been required for a first-class manually operated station.

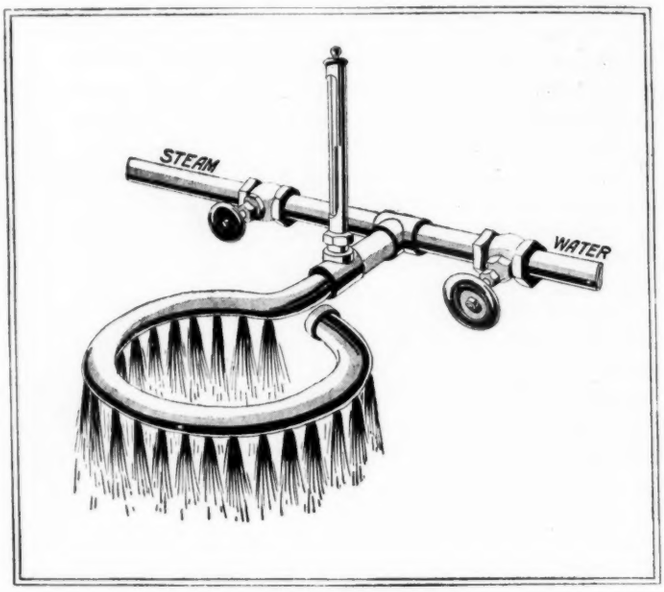
The design and construction of the station have been carried out under the direction of John M. Brabelle, electrical engineer of the Iowa company. Of the manufacturing company's representatives, L. B. Bonnett and A. C. Thompson, of the General Electric Co., have contributed liberally of time and experience in getting the station under way. The hydraulic engineering was carried out by the Fargo Engineering Co., of Jackson, Mich. The turbines and generators were furnished by the Allis-Chalmers Manufacturing Co., the control equipment, exciter set, transformers and underground cables were supplied by the General Electric Co.

Pulverized Coal for Central Railroads of Brazil

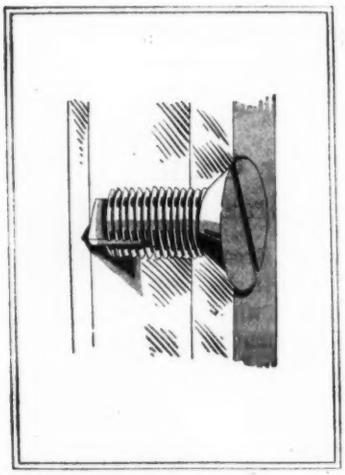
The Central Railroad of Brazil recently inaugurated a series of experiments with its new coal-pulverizing plant at Barra do Pirahy, which caused considerable interest and favorable comment in engineering circles, according to the *Commerce Reports*. The plant was furnished by an American firm and installed by one of its engineers. The pulverizer is described as being similar in construction to a cement plant. The coal, freed of its mosture, goes into a hopper and is pulverized so that 80 per cent. of it can pass through a 200-mesh screen. It is then passed to the locomotive by means of a conveyor screw and blast, thus bringing the ignitable powder to the mouth of the locomotive furnace, at which point combustion takes place. The first set of experiments were with American coal and were an unqualified success. The experiments were then continued with a mixture and finally with Brazilian coal from the Jacuhy district, until now somewhat problematically useful—"problematically useful" because it is a coal that does not burn economically in the usual lump form. It was, however, believed that, once pulverized, this coal would give good results and would prove to be adaptable to the needs of the railroads. The experiment, as reported, was an unqualified success and was hailed as an auspicious event that represents the solution of one of the most vital national problems in Brazil.

Some Practical Kinks F

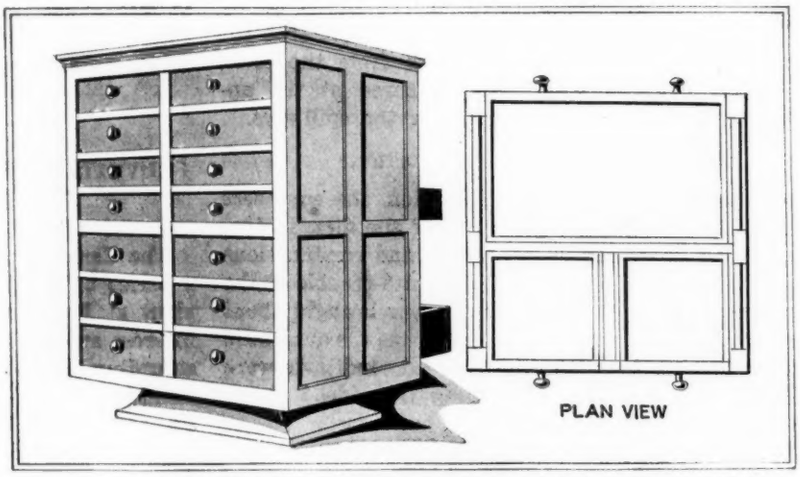
TINNING A CABLE END



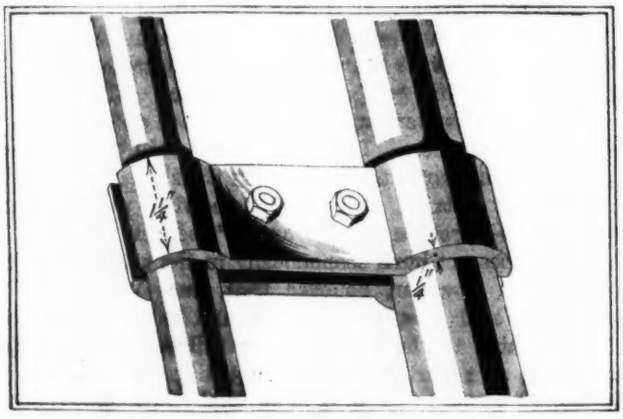
A HOME-MADE SHOWER BATH



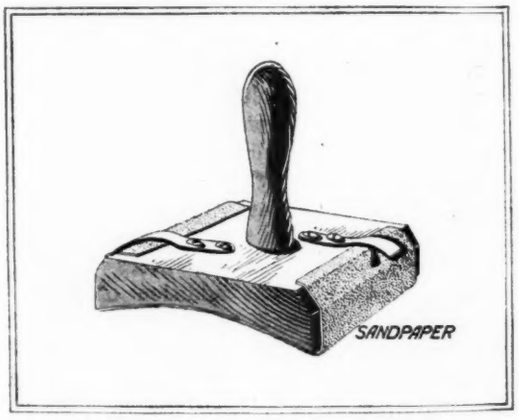
MACHINE-SCREW LOCK



A COMMODIOUS AND USEFUL ENGINE-ROOM CABINET

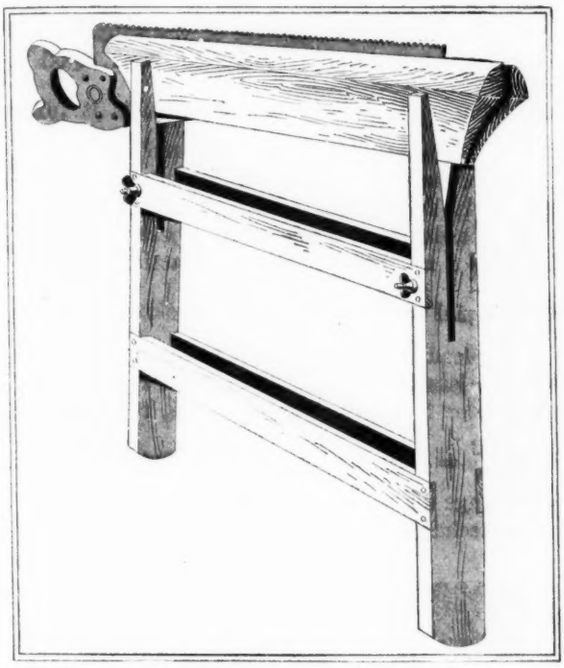


CONVENIENT PIPE-SUPPORTING CLAMP

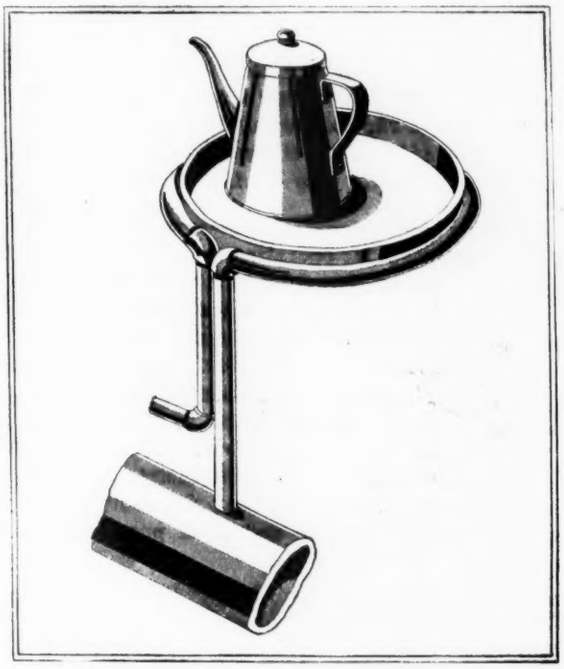


COMMUTATOR SMOOTHING BLOCK

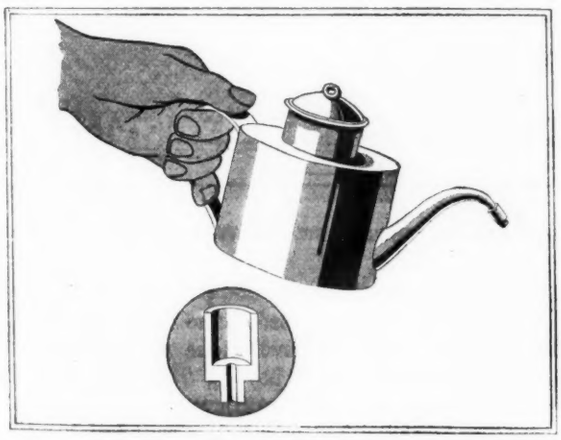
For the Power Plant



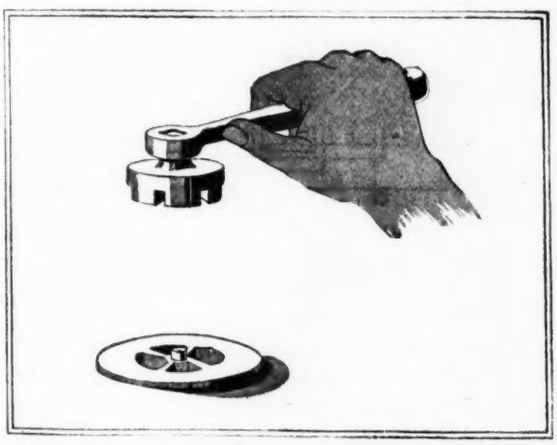
HOLDER FOR SAW FILING



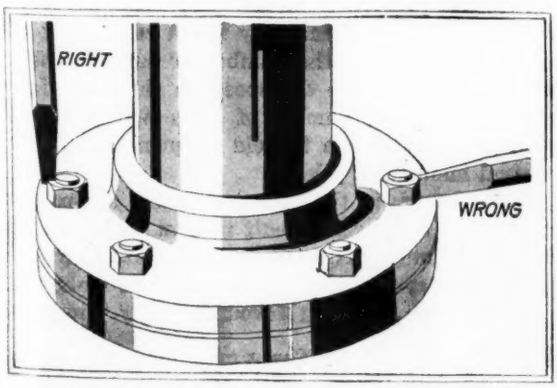
HOT-PIPE OIL-CAN STAND



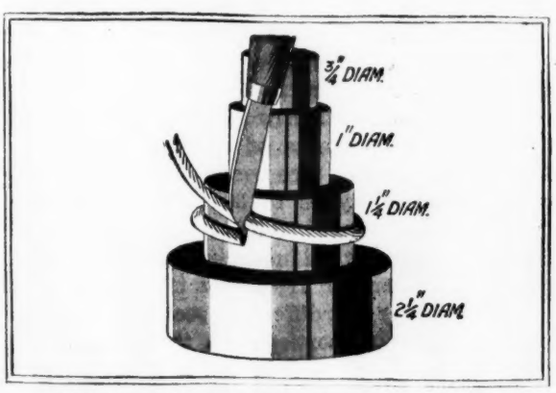
OIL-CAN NOZZLE FOR FILLING SMALL OIL CUPS



HANDY WRENCH FOR REMOVING PUMP VALVE SEATS



RIGHT AND WRONG WAYS TO SPLIT NUTS



USEFUL GAGE FOR CUTTING ROD PACKING

Reconnecting Induction Motors—For Changes of Frequency

By A. M. DUDLEY

The necessity of operating induction motors on a frequency other than that which they are designed for frequently arises. In this article the author outlines the various features that must be considered in the solution of this problem, along with some of the ways the motor may be made to operate under the new condition.

THE necessity for operating motors on a frequency differing from that for which they were originally designed may be the result of actually changing the frequency of the power supply and thereby affecting a number of motors in one installation, or it may result from applying used or repurchased motors on new circuits. At times such as those at the outbreak of the European War, when numbers of concerns were undertaking the manufacture of explosives and all sorts of munitions, the sudden demand for motors for the operation of machine tools and other purposes greatly overtaxed the available stocks and created a brisk demand for second-hand motors wherever they could be found. The installation of these machines on new circuits necessitated a change in frequency in many cases as well as changes in phase and voltage. Another instance of a wholesale change of frequency is the retiring of an existing isolated plant for the purchase of central-station power which may differ in frequency. This may result sometimes in changing the motors in a single plant, or it may involve a plant serving a town, in which case the motors in the entire district served must be arranged for the new frequency.

The commonest changes of this kind are from 25 cycles to 60 cycles and vice versa. There is also some changing from 60 cycles to 50 and infrequently 40-cycle motors are changed to 60 or the reverse.

The most important and immediately noticeable change in the motor when the frequency is changed, is that the motor operates at a different speed. This change in speed is directly proportional to the change in frequency. It was explained in the first article of this series (*Power*, Jan. 16, 1917) that the so-called synchronous speed, or the number of revolutions per minute made by the magnetic field of the stator is equal to the alternations per minute of the supply circuit divided by the number of poles, or it is equal to the expression $\frac{\text{cycles} \times 120}{\text{number of poles}}$. From this it follows at once that if the cycles are changed and the poles remain the same, the revolutions per minute will change exactly as the frequency.

As an example, a 4-pole motor operated on 25 cycles will have a synchronous speed (practically the no-load speed) equal to $\frac{25 \times 120}{4} = 750$ revolutions per minute. The full-load speed is usually about 3 per cent. to 5 per cent. less than the synchronous speed. If now this same motor is operated on 60 cycles, the speed will be $\frac{60 \times 120}{4} = 1800$ revolutions per minute. This immediately brings up two serious mechanical questions: First, is the mechanical design of the rotor such that it will stand this increase in speed, 240 per cent. of the original value? The peripheral speed of the rotor (that is, diameter in feet $\times$ 3.14 $\times$ revolutions per minute) should not be permitted to go beyond 7500 ft. per minute without consulting the manufacturer of the machine. Second, can the belting or gearing be suitably adjusted so that the speed of the driven machine or apparatus will remain practically unchanged? If these two questions cannot be satisfactorily taken care of, it will be necessary to change the number of poles in the motor winding also, so that the speed on the new frequency and with the new number of poles will be nearly the same as the speed on the old frequency and with the original number of poles.

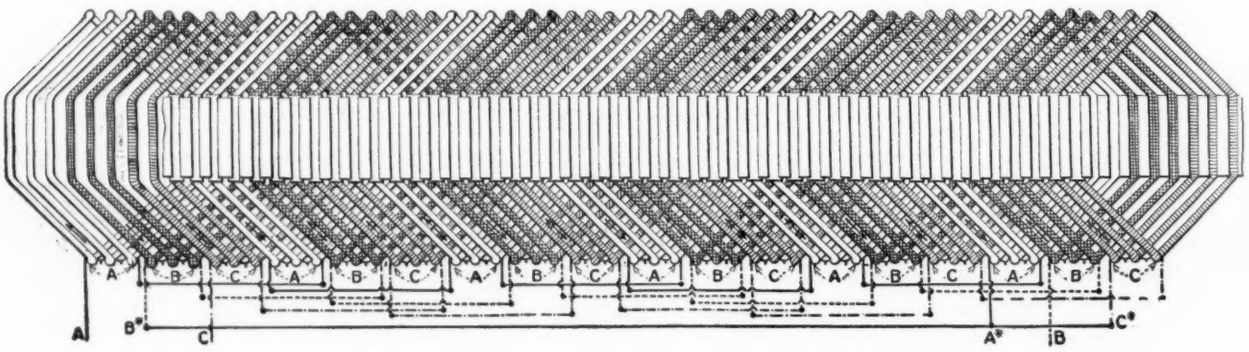


FIG. 1. SIX-POLE, INDUCTION-MOTOR WINDING CONNECTED SERIES STAR

For example, in the case just cited, a 4-pole motor operated on a 25-cycle circuit runs at about 750 revolutions per minute. The nearest combination to give this speed on 60 cycles would be to wind the motor for ten poles, and the resulting revolutions per minute would be $\frac{60 \times 120}{10} = 720$. There are, therefore, two conditions in case of a change in frequency—the first, when

the number of poles remains the same and the speed changes with the cycles, and the second, when the number of poles is changed so as to keep the original speed or as nearly so as possible.

Consider first the case where the frequency is changed and the number of poles remains the same. The resulting change in the speed in this case is assumed to be proper for the motor in question, and the gears or pulleys are changed so that the driven load will operate at the same speed.

The next thing that is affected by the change in frequency is the operating voltage. That is to say, if the frequency is raised, the voltage should be raised also and vice versa, if the conditions in the magnetic and electric circuits are to be kept normal. Assuming that the rotating magnetic field is to be kept at the same value and the frequency raised, this field will rotate at a faster rate and cut more conductors in a given time, which will immediately result in the generation of more voltage, or counter-electromotive force as it is called in a motor. It will be remembered that in the first article of this series attention was called to the fact that one of the easiest ways of thinking of an induction motor is as an alternating-current generator generating a counter-electromotove force almost exactly equal to the line voltage on which it is operated. In the present instance, then, if raising the frequency causes the motor to generate more of this back voltage, it will be necessary to oppose it by a higher applied voltage; or, speaking simply, if the frequency is to be raised the line voltage should be raised by the same amount to keep the same magnetic conditions as existed in the original motor.

Suppose that the frequency is raised and the voltage is not raised. If the same magnetic field existed and rotated faster, it has been shown that an increased back voltage would be generated. However, if the line voltage is not raised, the motor does not require any increased back voltage and hence it does the only other thing it can to keep the generated voltage equal to the line voltage, and that is to automatically decrease its own magnetic field to such a point that the new field rotating at the new speed will generate the same back voltage as the old field rotating at the old speed, and this electromotive force will be nearly the same as the applied line voltage, which has been assumed to be the same on both frequencies. The result of a decrease in the magnetic field would be a decrease in torque or turning effort, and this might result in a reduced horsepower output were it not for the fact that the speed increases and tries to make up for the decrease in torque

$$Horsepower = \frac{torque\ at\ one\ foot\ radius \times r.p.m.}{5252}$$

From this it follows that if the frequency was raised and the voltage left the same, the magnetic field might decrease and the torque decrease without lowering the horsepower by the same amount, since the speed increases and partly makes up for it. On most of the loads that are driven by motors, the driving effort, or pull, or torque is practically the same at all speeds. This is not true of centrifugal pumps or fans or similar apparatus, but is generally true of a great deal of industrial machinery. Since this is the case, it may be seen from the horsepower formula just given that if the torque is constant the horsepower will vary directly as the speed; that is, a higher speed will call for more horsepower and a lower speed for less horsepower. Going back to the frequency, a higher frequency means a higher speed and hence, directly, a higher horsepower, and a lower frequency means a lower speed and a lower horsepower. All these things work out automatically if the voltage and frequency are varied on the motor at the same time and by the same amount. This is for the reason that torque is the product of the magnetic field acting on the currents in the windings.

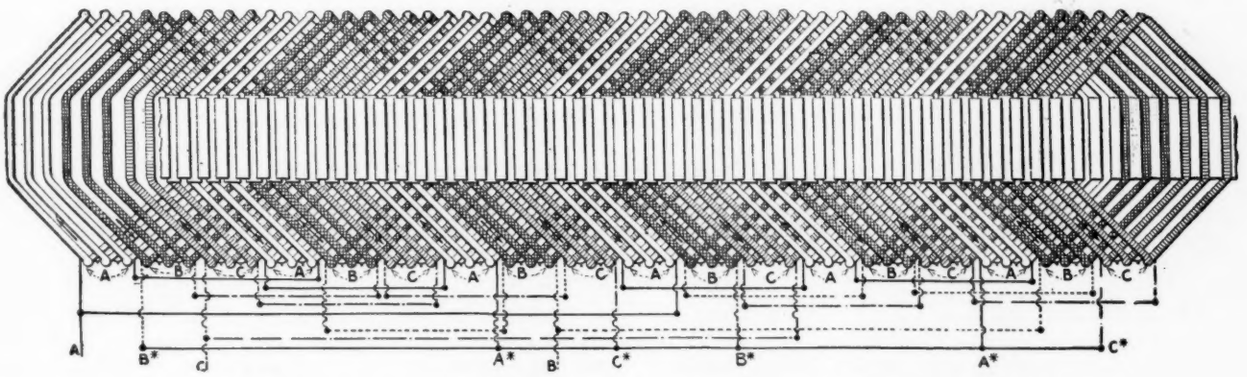


FIG. 2. SIX-POLE, INDUCTION-MOTOR WINDING CONNECTED TWO-PARALLEL STAR

If the heating of the machine is to be kept constant, the magnetic field and the currents in the coils should be kept as nearly the same as possible.

It was shown in the foregoing that if the field is kept constant and the speed increased, the generated voltage would increase, and hence the applied voltage should be increased also. This brings about a rule which may be most easily remembered in this form: *If the frequency on a motor is changed, the voltage should be changed in the same direction and by the same amount.* If this is done and the torque against which the motor is working is constant, the magnetic field in the iron will remain constant, the currents in the windings will remain constant, the speed and the horsepower will vary directly with the change in voltage and frequency, and the heating would remain constant were it not for the fact that the change in speed affects the fan effect of the rotor to some extent and the temperature rise will be slightly higher on lower speeds or lower on higher speeds.

A concrete instance of the foregoing would be to take a 50-hp. 440-volt 60-cycle motor and operate it on 25 cycles and $\frac{25 \times 440}{60} = 183$ volts, in which case it would develop $\frac{25 \times 50}{60} = 20.8$ hp. If 183 volts was not available, a connection of the windings should be selected which would have been equivalent to 880 volts on 60 cycles and this would be suitable for $\frac{25 \times 880}{60} =$ 366.6 volts on 25 cycles, which in many cases would operate satisfactorily on a commercial 440-volt circuit. In the case which is most commonly met with, which is changing from 25 to 60 cycles, this condition can often be taken care of by impressing twice the voltage on the motor on 60 cycles that was used on 25 cycles, such as operating a 220-volt 25-cycle motor on a 440-volt 60-cycle circuit, at about double the horsepower.

Theoretically, to follow the rule already given, the voltage on 60 cycles should be 2.4 times the value on 25 cycles, since $\frac{60}{25} = 2.4$. This would result in 2.4 times the speed and 2.4 times the horsepower. Practically, it is easier to get twice the voltage than 2.4, so the voltage is doubled and the horsepower considered as double also. In case it is not possible to get double the voltage on 60 cycles, the same result can be secured in another way. Suppose the original motor is operating on a 220-volt 25-cycle circuit and is connected series star as in Fig. 1. Suppose, also, that the available 60-cycle voltage upon which it is to run is 220. To get the effect of doubling the voltage, the motor can have its pole-phase groups connected in two parallel star, Fig. 2, for 60 cycles and it will then be affected in the same way as it would if the windings had not been reconnected but had been operated on 440 volts 60 cycles. On 60 cycles the motor would then run 2.4 times as fast and develop about twice the horsepower[1].

In some cases it would happen that the same horsepower was required on the new frequency and at the increased speed as on the original frequency. Hence, it would be undesirable to reconnect the motor so as to raise the voltage with the frequency, since this would result in twice the required horsepower and would mean operating the motor at all times at half-load and consequently somewhat lower efficiency and power factor than if it were fully loaded.

[1]See articles in the "Electric Journal," Vol. III, p. 400, by G. B. Werner, and Vol. VII, p. 680, by R. E. Hellmund.

Considering again the horsepower formula, it can be noted that if the horsepower is to remain constant, the torque must decrease as the speed increases and vice versa. Since the torque varies as the square of the applied voltage, it is evident that approximately the same horsepower can be kept with a changing frequency by varying the voltage applied to the motor as the square root of the change in frequency instead of directly as the first power. An example of this would be operating a 440-volt 25-cycle motor on a 550-volt 40-cycle circuit. The square root of $\frac{40}{25} = 1.26$. Then if $1.26 \times 440 = 554$ volts be used on 40 cycles, the magnetic density in the iron will be about 80 per cent of its 25-cycle value and the torque will be $\frac{80^2}{100} = 64$ per cent. of the 25-cycle value. Since the speed will be $\frac{40}{25}$ of that on 25 cycles, the resulting horsepower will be $\frac{40}{25} \times \frac{64}{100} = 1.02$ times its 25-cycle value or practically the same.

A similar instance would be operating a 50-cycle motor on 60 cycles and at 110 per cent. voltage to keep the same horsepower. Suppose in the latter instance it was not possible to juggle the generator or the transformers so as to get a 10-per cent. increase in voltage. It would then be necessary to reconnect the motor so that there would be $\frac{100}{110} = 91$ per cent. as many turns in series. One way of accomplishing this if the 50-cycle motor was originally connected series delta, as in Fig. 3, would be to reconnect it two parallel star (Fig. 2) for 60 cycles and the same horsepower. This would have the effect of increasing the applied voltage $\left(\frac{200}{1.73}\right) - 100 = 15$ per cent. However, since the frequency has increased 20 per cent. (50 to 60 cycles) and the speed also has increased the same amount, if the voltage is increased only 15 per cent. the magnetic density in the iron will be only $\frac{115}{120}$ of its 50-cycle value and the torque will be only $(\frac{115}{120})^2 \times 100 = 92$ per cent. of its 50-cycle value. The resulting 60-cycle horsepower rating as compared with the 50-cycle will be $\frac{92}{100} \times \frac{120}{100} =$ 110 per cent. (since the torque is 0.92 and the speed 1.2 of its 60-cycle value). Instances could be multiplied on this, and some further examples will be given in a later article giving practical applications of the principles laid down here.

The fact that raising the frequency, and hence the speed also sometimes results in a horsepower rating greater than that actually required, leads at once to a

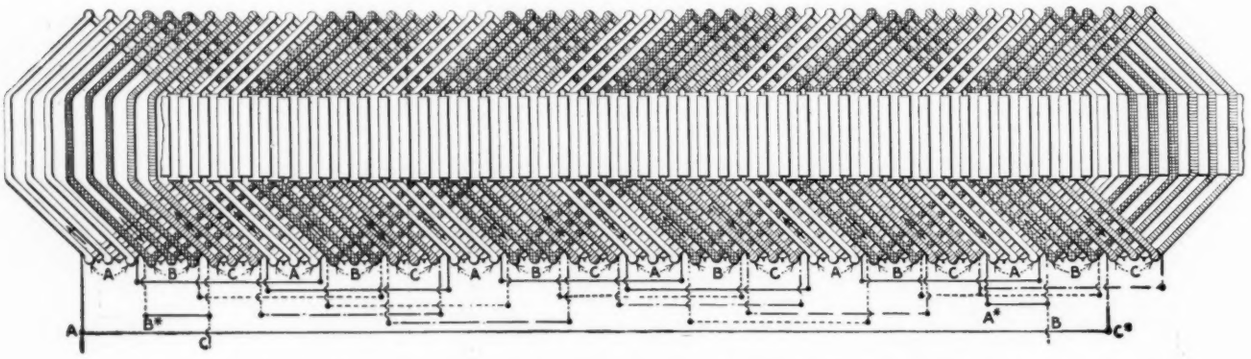


FIG. 3. SIX-POLE, INDUCTION-MOTOR WINDING CONNECTED SERIES DELTA

word of caution regarding the converse proposition; namely, that in reducing the frequency on a motor and keeping the same number of poles, it should be figured that the horsepower will decrease exactly in proportion to the decrease in frequency and the consequent decrease in speed. The physical conception of this is that if the frequency and voltage are varied together and the motor is working against the same torque, the magnetic density in the iron will remain the same and the current in the copper of the stator and rotor will remain substantially the same, but the horsepower will rise and fall with the voltage and frequency, since it is the product of the torque and the speed divided by a constant. If it be imagined that the voltage and the frequency be carried down to zero and the motor just came to a standstill, it could be seen that the motor was developing full-load torque at standstill with no more than full-load current flowing in its windings.

The foregoing at once suggests a method that is sometimes used for starting a large squirrel-cage motor or a group of small motors where such motors constitute practically the only load on the generating unit from which they are operated. While the motors and the generator are at standstill, the motors are connected electrically to the generator by closing all line switches. The generator field is next excited to its normal value. The steam engine or the waterwheel is then started slowly from rest, and as the generator builds up in speed the motors come right up along with it and no more current is required in the motor windings than is represented by the torque against which they are starting. This gives the best physical picture of the voltage and frequency building up together from zero to normal value and yet the motors exerting a constant torque from standstill to normal full-load speed under these varying conditions.

The example just cited brings out the fact, also, which was mentioned in another article (*Power*, July 31), that practically all changes in operating conditions could be considered equivalent to changes in voltage and so calculated and used. So it is with the change in frequency—if the torque is to be kept constant with the same number of poles and the horsepower is to vary with the speed, the voltage should be varied with the frequency or the winding connections changed to produce the equivalent. However, if the horsepower is to be kept constant at any and all speeds with the varying frequency, then the voltage should be varied as the square root of the change in cycles. (*The case of a change in the number of poles in combination with a change in frequency will be considered in the next article.*)

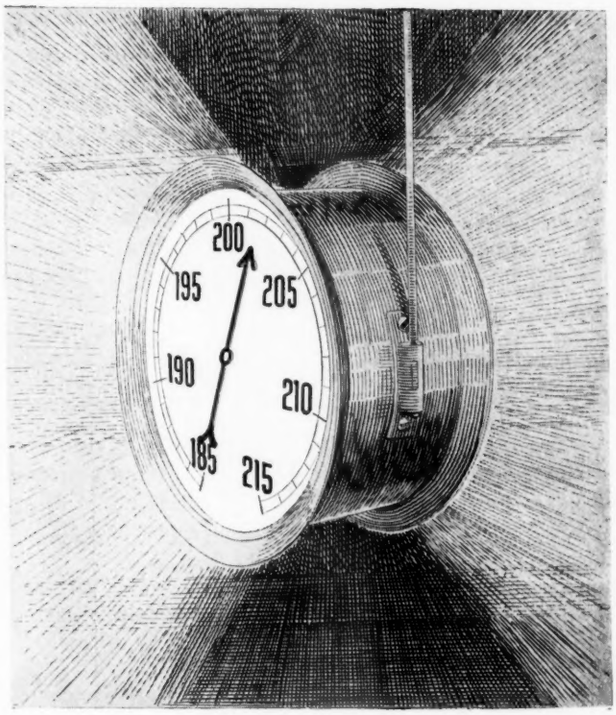
Double Illuminated Dial Pilot Gage

The fireman is sometimes unable to see the reading on the steam gage of the boiler he is firing because it is so high above his vision or so improperly illuminated that it is difficult to determine at what pressure the pointer is indicating.

The Ashton Valve Co., 161 First St., Boston, Mass., has for a long time made a single illuminated dial pilot gage for use in large power plants. It is usually placed at one end of the boiler room against the wall in view from the firing aisle.

Many boiler rooms are of such length that a single-dial gage is not easily seen from the far end, and the company has designed a master pilot gage with double illuminated dials for use in large plants where it is of advantage to have a gage that can be distinctly seen from any location of the stoking aisle and from a distance. This gage is to be placed at the center of the boiler room, and as it is provided with brackets on the sides, it is easily suspended from any convenient support overhead (see illustration).

Both dials are of opal glass and are so spaced that an electric-light globe can be placed inside the gage case, to illuminate the dials and pressure graduations. These graduations show only part of the pressure scale,



DOUBLE ILLUMINATED DIAL PILOT GAGE

such as would be included in the ordinary range of pressure, and thus admit of the graduations being so far apart that large figures can be used. This makes it easy for the firemen to read the gage and to note slight variations in the pressure, thus enabling them to maintain a steady steam pressure.

It is the general impression that CO_2 recorders get out of order very easily and require considerable attention, an impresion that is borne out by the experience of many engineers. The CO_2 recorder in a small plant is usually put in charge of the chief, who is often the busiest man around the plant. He has his routine duties, subject to change in an emergency, but if the recorder is not working right, he will not call that an emergency, and may let it go for a day or a week. How different it would be if the chief assigned one of his men to the instrument! A technical man is not needed to take care of it, although a certain amount of mechanical knowledge or instinct is very necessary. This man would be responsible to the chief for keeping the machine running, and would give attention to it at the proper time.

Conditions in the Power Industry

By LUDWIG W. SCHMIDT

A digest of the reports of the United States consuls on the power situation in the various parts of the world and the influence of the war upon this important industry.

THE most characteristic influence of the war on the power industry of the world has been the general increase in operating expenses in consequence of the rise in the price of many important materials, machinery and, incidentally, labor. Reports about increases in rates therefore come from several sides. The operating costs of the tramway system of Sheffield, England, increased from 14.87c. per car-mile during 1915, to 16.9c. during 1916. On account of the increased cost of operation one-cent fares for adults were abolished (C. R. 157).[1] The Leeds Corporation Electricity Committee, of Leeds, England (C. R. 165), reports, for the year ending Mar. 31, 1917, an increase of 22.7 per cent. in the number of units sold. The power sales show an increase of 46.6 per cent., while the sales to the tramway department showed a decrease of 29.6 per cent.

War Increases Cost of Operation

The influence of the war on the cost of operation is also shown by the fact that the municipality of Amsterdam, Netherlands (C. R. 176), is now charging a higher rate for electricity if the consumer uses above a certain quantity instead of charging less, in order to keep down the consumption of power. The rates for electric current have been raised to such a point as to make it undesirable to change from the use of gas to electricity. It is hoped, in this way, to keep down the demand for installation materials, which are practically not to be had any more. The tramway fares also have been increased.

The Moscow, Russia, electric-light companies have raised the price for electricity 24 per cent. above former cost (C. R. 186).

The difficulty of obtaining coal in sufficient quantities, which has greatly increased the cost of power-plant operation in most countries, also has had its beneficial results by encouraging an increased use of the existing water-power resources. Norway, especially, has been benefited in this way. Much of the recent influx of wealth into Bergen has been invested in hydro-electric development in Hardanger, Söndhordland and Nordfjord districts, reports Consul Charles Forman, from Bergen (S. C. R. 10a).[2]

Among the new concerns and those which have lately enlarged the scope of their activities are the following: A. S. Bjölvefossen, at Indre Aalvik on the Hardangerfjord; a. s. Bremanger Kraftselskab, at Bremanger coast island, about 100 miles north of Bergen; and a superphosphate factory at Knarrevik on a coast island just outside Bergen. The two concerns first-named will engage in the manufacture of carbide. The total investment in hydro-electric development in the district is about $13,400,000.

Consul Maurice P. Dunlap reports from Stavanger, Norway (S. C. R. 10a), that the Electric Furnace Products Co., an American enterprise, is developing the water power in Saude. Another concern formed in that neighborhood during the last year is the Florli Co., with a capital stock of $268,000, which will develop the water power of several mountain lakes emptying into the Lysefjord. The increased needs of Stavanger for power are relieved by temporary installations. The city of Stavanger has taken a lease of 12,000 hp. developed by the Florli Co. (C. R. 185).

The power from the Florli power house will be transmitted to the power station of the city by a copper-conductor line carried on wooden poles. One span, crossing the Hogsfjord, will be one mile long. At Sirdal, in the southern part of the Stavanger district, arrangements are being made to develop one of the waterfalls, which will generate 12,500 hp., at an estimated cost of $1,600,000 and a yearly expenditure of $165,000. The power is to be transmitted 53 miles. Also the water sources at the Lake Oltedal, from which the present hydro-electric power of Stavanger comes, will be utilized in such a way as to produce another 5000 hp. The equipment of most of the new power stations comes from either Germany or the United States. The latter during recent years has taken an increased interest in hydro-electric power development in Norway, which apparently promises a good future.

The Stavanger Electro-Steel works are extending their plant by adding a new rolling mill of American design. This company has taken over the shares of a power company utilizing the Jorpeland water course and will supply 5600 hp. to the steel works (C. R. 174).

After-War Power Development in England

A better utilization of the power resources is expected to be one of the leading features of after-war power development in England. A special committee appointed by the Board of Trade has issued a preliminary statement outlining the policy recommended (C. R. 162). In this statement it is said "that a highly important element in reducing costs will be the general extension of the use of electric power, supplied at the lowest possible price, and it is by largely increasing the power used in the industry that the average output per head, and as a consequence the wages of the worker, can be raised; that the present system, under which a supply of electricity is provided in a large number of small areas by separate authorities, is the result of a policy adopted at a time when the applied science of electrical engineering was in its infancy and is incompatible with anything that can now be accepted as a technically sound system; that the interconnection of existing supply stations, however desirable in itself, cannot alone meet the requirements of the situation; that a comprehensive system for the generation of electricity, and where necessary reorganizing its supply, should be

[1] C. R. indicates copy of "Commerce Reports" of current year.
[2] S. C. R. indicates "Supplement Commerce Reports" of current year.

established as soon as possible." Changes in the organization of the electrical-power distribution systems in England, therefore, most likely can be expected in the near future, and in fact are already under way.

An English concern has applied to the British government for a license to establish an electric-lighting and power plant in Madura, India. The city has 134,000 inhabitants, and if the license is granted, the scheme will be the most important of its kind in that part of India, with the exception of the lighting systems at Madras and at Bangalore (C. R. 190). The demand for the plant is calculated to be approximately 5000 private lamps, 1000 fans and 700 public lamps for the town (C. R. 184).

Electric Power in China

In China the expansion in the application of electric power has also continued during the war. This is especially gratifying considering the not very favorable conditions just now operating against industrial development of any kind in that country. Consul General Thomas Sammons reports from Shanghai (S. C. R. 52c) that the Shanghai Municipal Electric Works have increased their output during the last year considerably. They sold 14,285,888 kw.-hr. for private lighting and 1,058,772 kw.-hr. for public lighting. The use of power for heating purposes increased from 679,704 kw.-hr. in 1915 to 899,585 kw.-hr. in 1916. The most rapid progress, however, was made in the sale of electricity for power. In 1914 only 15,230,639 kw.-hr. were sold and in 1915, 30,633,455; the sales increased during 1916 to 42,042,853 kw.-hr. The total connected motor load represents 20,340 hp. Introduction of electric vehicles has led to an increase in power consumption.

Consul General P. S. Heintzleman reports from Canton (S. C. R. 52d) that the Kwangtung Electric Supply Co. has added many customers during the year, but the additional cost of coal and imported machinery reduced the profits. The Chi Ming Electric Light Co., in Chengtu, writes Consul M. S. Myers in Chungking (S. C. R. 52d), contemplates the installation of a new and more extensive equipment. There are four electric plants in that district, in Chungking, Chengtu and Luchow. The Chungking plant, which has been in operation for six years, is now in bad condition. The two small plants in Chengtu have not been operated with much success. The Luchow plant, opened December, 1916, operates at 100 volts and has a capacity of about 500 lamps.

Profits of Electric-Light Companies

Vice Consul Horace Remillard writes from Swatow (S. C. R. 52d) that the Kaiming Electric Light Co., which furnishes current for 13,000 lamps, has declared a dividend of 8 per cent., and has made a net profit of $9802. Two new electric-light plants, in Meihsien and Hingning, have been put in operation. The electric plant in Foochow, writes Consul Albert W. Pontius (S. C. R. 52e), has been benefited by the high cost of kerosene and there are now 36,000 lights installed in Foochow. During the year the company extended its wires seven miles. Profits were estimated at $70,000. A steam turbine of 1000-kw. capacity was purchased and is being installed.

A great many power stations are in operation in the Amoy district (C. R. 188). The Amoy Electric Light and Power Co. supplies 16,000 private lights and 4000 street lights. Current is supplied to 300 fans, but there is no power load at present. The company supplies service to 2100 families. During 1916 a 13 per cent. dividend was paid.

The electric-light service provided in Kulangsu by the Shanghai Electric and Asbestos Co., will be extended very shortly as the present installation is insufficient for the demand. A Japanese company and several other interests applied for the right to install the new plant. In Changchow, 33 miles from Amoy, a new plant under the direction of the newly organized Changma Electric Light and Power Co., a Chinese company, is under construction. It is intended to erect a plant consisting of one 50-kw. and one 30-kw. generator to be driven by gas engines. The distributing system will be 3-wire 220-440 volts direct current, the lamp voltage being 220. There are plants in Chio-he and Chuanchow; the latter plant is going to be enlarged.

The outlook for an increase in the number of power stations in the Amoy district are good. With the Germans eliminated and the British firms unable to make deliveries, the Japanese at present have an open field. They have adopted the liberal credit system of the German concerns. Their equipment, says Consul C. E. Gauss, "is poor, but the question of financing plants is so all-important that their credit and financing terms are often sufficient alone to win the contract."

Power Development in South America

Great activity in power development is shown in South America. Of special interest in this respect is the increasing influence of the Norwegian electric industry in that field. The Companhia de Bondes Electricos Campo Grande Guaratiba, with a capital of $812,500, has just taken over a concession for the construction of an electric tramway in the federal district of Brazil. This company has its head offices in Christiania, Norway (C. R. 194). The state of Rio Grande do Sul, Brazil, today has about 45 different power companies furnishing light and power (C. R. 184).

In Maracaibo, Venezuela, improvement in the supply of electric energy has been made by the introduction of power supply during the day by the Maracaibo Electric Light Co. This company is under the technical control of an American chief engineer. The company has introduced the United States standard three-phase 60-cycle system with standard voltages (C. R. 184).

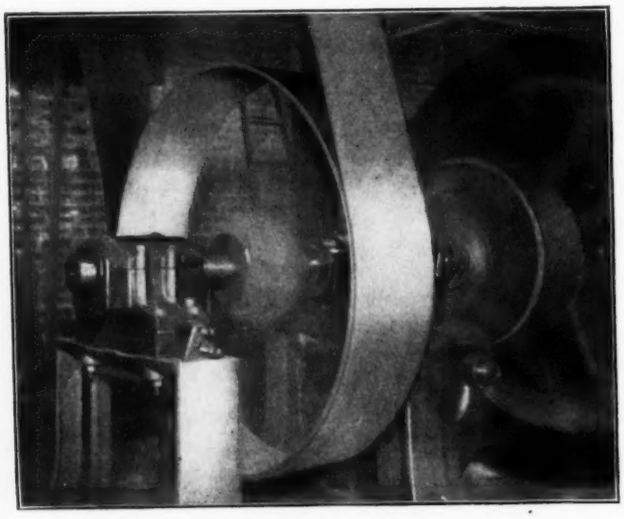
The La Guaira Harbor Corporation, La Guaira, Venezuela, which owns and operates the Macuto La Guaira Maiquetia Electric Ry., has made plans for developing power from a small stream in the neighborhood. The stream only gives a 6-in. flow through a 2-ft. weir, but a 2000-ft. fall can be obtained. The municipality of Calabozo, Venezuela, has made an agreement for the erection and operation of an electric light and power plant (C. R. 175). Consul Samuel C. Reat, in Guatemala City (S. C. R. 29a), points to the fact that the largest electrical installation in Guatemala is under German control and that the concession is practically a monopoly. The further development of electric lighting and power in small units on the larger coffee, cane and other plantations offers an opportunity that can be safely considered.

An extension of the service of the Cienfuegos Electric and Power Co., in Cienfuegos, Cuba, is contemplated, but so far the necessary preparations seem not to have been completed. It is also reported that this company was taken over by the Cienfuegos, Palmira-Cruces Electric Railway and Power Co. This company is organized under a charter of the State of Maine (C. R. 206).

The City of Melbourne, Australia, has been discussing the possibility of building a power plant that would utilize pulverized coal or lignite for fuel (C. R. 164). The Mount Lyell Co. intends to develop the water power of Lake Margaret in Tasmania. An investigation indicates a possibility for a 30,000-hp. plant. The chief electrical engineer to the Public Works Department of New Zealand recommends the use of the water powers of Lake Waikara Moana for the Hawks Bay district, the Arapuni Gorge or some other place to be selected for the Auckland district and the Mangahao River for the Wellington district. It is estimated that the Wellington plan providing for a production of 25,000 hp. will cost about $5,000,000 and the Auckland plan, securing about 30,000 hp., would cost $6,000,000. The recommendation asks for the early and simultaneous start of the Auckland and Wellington schemes, leaving the Lake Waikara Moana plan for the time being. Survey work in all cases is fairly well advanced, and it is said that the work could be undertaken at once if the necessary pipes and machinery could be secured during the war. This, however, seems to be practically impossible (C. R. 185).

Oil Engine Extension Driving Pulley

In oil-engine practice it is common to belt from one of the flywheels to a lineshaft in the factory. If the belt is tight or heavily loaded, the wear on the bearings



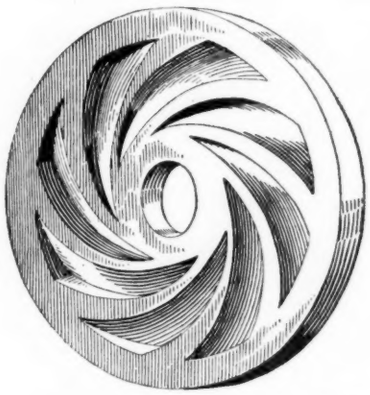
EXTENSION BEARINGS AND CLUTCH

is considerable in the course of time. Besides this there is the factory shafting load to start with the engine.

In one instance a 60-hp. oil engine was fitted with two flywheels, one on each side of the center crank. The manager of the plant, who was somewhat of a mechanic, decided that driving the factory from the engine flywheel was not the best practice. He therefore erected two independent bearings in line with one end of the crankshaft, and between these bearings a driving pulley was keyed to a short shaft, one end of which extended beyond the inner bearing a sufficient distance to secure one side of a friction clutch, the other side of the clutch being keyed to the extension of the engine shaft. This arrangement brought all the belt pull on the two outer bearings, which were independent of the engine proper. In this particular case the belt pull was nearly vertical from the driving pulley.

Worden Turbo Pump Valve

The tendency of the ordinary disk pump valve is to seat in the same place at every stroke of the plunger. The design of the Worden turbo pump valve is such that it does not seat twice successively in the same place, because it is given a rotary motion each time it is lifted from its seat. As the illustration shows, the valve



WORDEN TURBO PUMP VALVE

is made with several pockets that are set at an acute angle. As the liquid in passing through the valve seat strikes the square side of the pockets, the valve is made to turn. This allows the valve to wear evenly and as a consequence eliminates one of the causes of slippage.

This valve disk is manufactured by the John-Roger Co., Coopersville, Mich.

Heat Rejected to the Condenser or Atmosphere

The heat in a pound of steam at 150-lb. gage and 100 deg. superheat is, roughly, 1250 B.t.u. Used in a turbine exhausting at 28-in. vacuum, 80 per cent. quality, the heat utilized is about 350 B.t.u., or 28 per cent. and that wasted is about 900 B.t.u., or 72 per cent. The heat remaining in the condensate is about 70 B.t.u., or 5.6 per cent., and can be returned from the hotwell to the heater, and thence to the boiler, so that under the most favorable conditions 72 — 5.6, or 66.4 per cent. of the heat per pound of steam is carried away by the condensing water. With the turbine or auxiliaries taking steam from the superheated main supply and exhausting at atmospheric pressure, 90 per cent. quality steam, the heat in the exhaust would be about 1055 B.t.u. per pound; or 1055 ÷ 1250 = 84.4 per cent. of the heat remains in the exhaust steam.

Editorials

What the Engineer Can Do

STATIONARY engineers throughout the country, who are above the age limit for enlistment in Uncle Sam's service, are wondering what they can do to help in winning the war. Doubtless each can say: "I have purchased Liberty bonds of both issues, subscribed to the Red Cross fund and have cut down on unnecessary food consumption. What more can I do? I am not wasting anything that can be used by the boys at the front or by those who are getting ready to go. It would seem, then, that I have done all I can."

Is the last statement true? To be sure, a soldier cannot use coal or steam, but he can and does use the articles that they produce. As has been said so many times in various ways, many of the stay-at-homes will do their part in winning the war just as surely as will the men with the guns, but in a different way and under conditions that are practically safe.

Here is something worthy of the attention of every engineer. The National City Bank of St. Paul, Minn., in a recent issue of its bulletin, presented an analysis of the coal consumption and average operating efficiency of the steam engines of the United States, showing that on a conservative estimate, fifteen million tons of coal could be saved every year if every steam engine in the country was as efficient as the more modern and better-designed power plants. If this statement is correct, and there is no reason to doubt it judging from the steam consumption of many engines with which we are familiar, there is an opportunity right in the individual power plant for each engineer who would serve the Government in its conservation efforts.

How? By carrying out the practical methods of power-plant practice that we have advocated for years. Put the plant in such a condition that the heat energy in the coal will be directed through the various channels to obtain the highest possible results.

It is likely as much the fault of the plant owner as it is of the operating engineer that probably less than fifty per cent. of the heat units contained in the coal burned is absorbed by the boiler. Why? Because the engineer, having requested this or that in equipments, was refused and he very naturally concluded that if the owner who is paying the bills is not interested in lower power-plant operating costs, there is no reason why he, the engineer, should worry about the situation.

At the present time the United States is engaged in a war, the end of which is not in sight. To many of us it appears as if it will last many months, perhaps several years, more and thousands upon thousands of tons of manufactured articles, from clothing to munitions, must and will be supplied to our soldiers and our allies.

Coal is the agent that has the most to do in the production of the supplies required by our fighting boys. Many plants are operating day and night in order to deliver the greatest output possible. Because of this and other reasons more coal is being consumed than in previous years, so much so that in many localities there is a grave shortage.

Here is where the engineer who thinks that he has done all that he can, can do his part for his country. Never mind whether the plant owner has been in sympathy with your endeavors to better plant conditions. Forget him and think of the boys in the trenches. Remember that every pound of coal saved will prolong the time when a new cargo of coal will be required and for every ton saved just so much will be had to carry on such industries as are working on war supplies.

Get after the air leaks in the boiler setting. It may take a little extra work, perhaps on your own time, but what of it? Remember while doing it that the boys "over there" are putting in their time in the trenches, standing in mud, exposed to the rain, the snow and the cold, to say nothing of shell fire, trench raiding and the influence of the horrors of war all about them.

Watch the fireman and discharge him if he insists on leaving the furnace doors open while he is lighting his pipe. If the plant conditions permit, insist that the fires be burned as low as possible before cleaning and thus prevent combustibles from being thrown out upon the ash pile, and do not allow a goodly portion of the coal on the stoker to go to the ashpit because of careless handling.

Another avenue for saving is by cleaning the boiler tubes and in so doing increasing the heat transfer to the water in the boiler. This also applies to the heater. Why permit the feed water to go to the boiler one degree below what could be obtained if conditions were more favorable, especially if a little attention will save the heat that is so often lost in exhaust steam?

Are the steam pipes properly covered? If not, here is an opportunity to save a few more heat units. Remember that cool surfaces condense steam and all such is just that much less steam to be delivered to the machine, which must be evaporated in the boiler again provided the condensate is returned.

Here is another chance to save the coal. What becomes of the condensed steam? Does all of it come back to the boiler, and if not, why not immediately make such pipe connections as to bring it back? Oily returns? What of it? There is apparatus to take care of just such a condition.

How are the engine valves and pistons? Many of them leak excessively. Why not test out some Sunday and make sure? Do it for Uncle Sam. Why not give the plant a general house cleaning and eliminate the needless waste? Don't say it can't be done. Prove to the contrary. Surprise yourself and your employer by the results that are sure to be obtained. Until you have done all that you can in the direction of power-plant economy, you cannot justly lay claim that you have done your part in serving Old Glory and the U. S. A. for which our boys are fighting.

Governmental Insistence Upon Efficiency

A FEW years ago Mr. Thorne's letter on page 805 would have been accepted without comment. *Power* has printed numerous arguments and editorials based upon the premise that the only concern of the state was for the safety of its citizens, that the efficiency of the plant was the affair of the owner or the man who paid the coal bills, and that all the examiner of an applicant for an engineer's license needed to establish was that the man was capable and qualified to operate the plant for which he sought the license without menace to the public safety.

But the last few years have brought a remarkable change in the minds of publicists and in the attitude of the public regarding the relations of the individual to the community. Not so many years ago the managers of the railways were resenting any interference by the Government with their manipulation of their own property. It is now universally recognized that the people are allowing railway corporations to control the highways of commerce rather than to do it themselves upon the assumption that the service is being rendered equitably and at cost plus a fair profit. A railway company cannot any longer lawfully use its property, absolute although its ownership of it may be, to favor particular localities or interests, and cannot inflate its capital so as to be able to claim a profit upon blue sky. The people have asserted their right to the service at cost plus a fair profit, and the right has been recognized.

A while ago, and one may hear it even yet, owners of boilers were resenting any governmental supervision of their design, construction, installation and operation as an unwarranted interference with the use of private property. "Let us alone," they said. "The boilers are ours. We are responsible for them, and if we blow them up we must stand the damage."

But there are some damages that the courts cannot adjudicate and that money cannot requite. The conviction grew that the public had a right to protection from such damages. States have begun to adopt laws forbidding the operation of unsafe boilers by incompetent attendants. Dr. F. R. Hutton, Past President and Honorary Secretary of the American Society of Mechanical Engineers and Vice President of the American Museum of Safety, in a masterly argument before the Uniform Boiler Law Conference at Washington in December of last year established the thesis that "an industrial accident—and a boiler rupture or failure is such an accident—is an economic loss and an indefensible blunder from which the community has a right to be defended, and by ordinance or legislation," because such an accident involves far-reaching losses involving expense to the community and tending to increase the cost to the user of property of the class of that destroyed and of products of the class the manufacture of which has been interrupted.

A boiler explosion is startling by reason of the concentration of a lot of waste and destruction in a few seconds, but its cost, widely distributed and inclusive as it may be, does not equal that of the numberless preventable wastes which are going on all the time. It may appear that a man having bought and paid for a carload of coal is free to use it as he pleases. Most people would have conceded it a little while ago. But the exceptional conditions of the past few months have forced home upon us the fact that he is not; that every ton of coal that he wastes, makes every other ton of coal that anyone buys cost more; that every time an engine breaks down and interferes with the continuously efficient operation of a factory, it makes the product of that factory cost more per unit; and that the consumers collectively, who are supposed to get things at cost plus a fair profit, are interested in having that cost as little as possible and justified in insisting that avoidable wastes be eliminated as factors of that cost. And so Dr. Hutton wrote another thesis. It was printed on page 774 of *Power* for June 5 of this year, in which he demonstrated very convincingly that the regulation of power plants is warranted on the grounds of efficiency as well as of safety.

Coal Conservation in the Ice Plants of Toledo

COMMENDABLE patriotism is shown by the manufacturers of artificial ice in Toledo, Ohio. The ice men of that city have shut down all but one of the plants in the city making artificial ice so that the most economical load factor may prevail in this plant so long as it meets the demands. Whent the consumption exceeds the production of this plant, another will be started, and so on, the aim being to operate at one time only enough plants to run at the best load factor with each, thus cutting down the fuel consumed per ton of ice manufactured. Every effort is being made to harvest the greatest possible amount of natural ice during winter.

At the recent meeting of the Eastern Ice Association at Atlantic City, quite general approval of the Toledo plan was voiced by those attending the convention, and it would not be surprising if the ice men of the country followed Toledo's initiative.

The electric-light men say that the amount of coal required to light the city's streets while the sun is still high in the heavens and maintain the Great White Ways is infinitesimal and would never be found if these practices were stopped. The street-railway men claim that the amount of coal required to heat their trains would be such as to make their compliance with the orders of the public-utilities commissions so to do entirely impracticable. How does the amount of coal required to light a city during daylight hours and run a lot of nonessential display lights compare with that required to keep the cars at a comfortable and healthful temperature?

"It is no longer cheaper to pay for coal than to educate the fireman," says Doctor Manning, Director of the Bureau of Mines. Quite true. But have you noticed that since the price of coal began soaring, many power-plant owners have become convinced that it is no longer cheaper to pay for coal than to buy the few steam traps and the boiler-room equipment their engineers have heretofore fruitlessly recommended in order to conserve the B.t.u. supply?

Correspondence

Engineers' Examinations

I was interested in the article by J. A. McGilliviary in the issue of Oct. 30, page 605, and agree with him that engineers' examinations should be based on practical power-plant operation, if he means to include boiler design, valve gears, etc., for knowledge of their principles to promote safety.

The point of his article that I wish to discuss or question is his idea that examinations should have for their groundwork mainly matter pertaining to economical operation and efficiency. While it might be well in some ways for the employers and for the engineers if such matter were also included, it must be borne in mind that the object of examining engineers is, from the viewpoint of the public and legislative bodies, one of safety and not for the purpose of determining his economic value. He must be capable of safe operation for the protection of the general public, not the owner, except as the owner is one of the general public. Therefore, the groundwork of the present examinations is correct when the purpose is considered.

Of course, as he says, the manufacturers build the engines right as to cutoff, throw of eccentric, etc.; but he must remember that just as soon as the engine is started, wear begins to take place and parts tend to get out of alignment, the position of different parts relative to other parts is altered, governors may stick, steam pressure varies, and in the case of boilers, corrosion weakens the shell. To keep machines safe the engineer must know the principles involved, and that is the reason for their place in examinations. A man examined mainly for his knowledge of efficient operation might, for example, get good indicator diagrams, a quiet-running engine and economy and therefore be considered entirely satisfactory, yet possibly next day have a wreck through failure of the governor or valve gear to function properly. It would take months of efficient operation to save enough to pay for one shutdown.

It is generally hard to get license laws passed, as the legislatures only consider them as questions of safety. Other considerations would cause the public to view the law as favoring a class, and this view would be increased if efficiency and economy in operating was made the main object of an examination. These laws are usually asked for by engineers, but passed by legislative bodies as protection to the public.

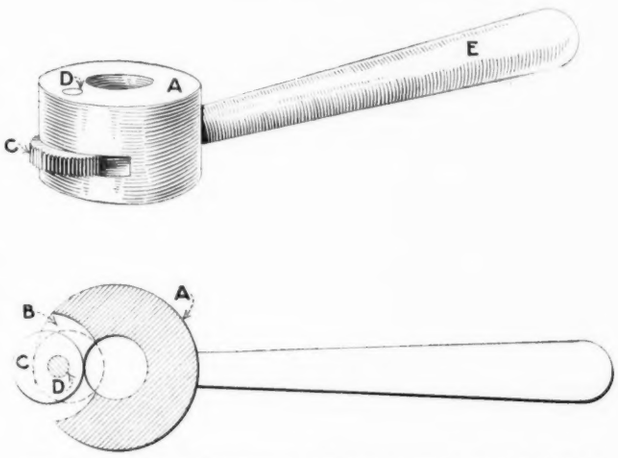
Subjects of economy, lubrication and the like are up to the engineer to study for his own protection and advancement and not of vital interest to the general public (except economists). Nine times out of ten the owner will not be able to determine whether an engineer is really efficient or not when upkeep and everything is considered and will pay all engineers alike.

Mr. McGilliviary says that the whole engineering profession is striving for fuel economy and efficient operation. He should remember that the first and main duties of an operating engineer are safety and continuous operation. There is no question but that engineers should be well informed along the lines he suggests, but I do not agree that they should be the groundwork of an examination.

Lodi, N. J. WILLIAM C. THORNE.

A Home-Made Stud Wrench

The illustration shows a stud puller that I have made and used to advantage. The body *A*, made of machine steel, is slotted at *B* to receive the eccentric roller *C*, pivoted on *D* and knurled to grip the stud firmly. In



WRENCH FOR INSERTING OR REMOVING STUD-BOLTS

operating, the device is slipped over the stud, with the roller *C* near the bottom, gripping the blank portion. If the stud is to be withdrawn, *C* is swung to the right, and if the stud is being put in, it is swung to the left, till the teeth grip the stud by a pull on the handle.

Brooklyn, N. Y. WILLIAM FORRAY.

Charging the System with Ammonia

Under "Inquiries of General Interest" in the Sept. 25 issue of *Power*, L. G. asks, "How may it be known what amount of ammonia charge should be supplied to an ammonia refrigeration system?"

Your answer is correct as to the cubical contents of the piping. This gives the approximate quantity of ammonia needed to charge the system. When it comes to charging, the head pressure, which you say to be governed by, is not always a reliable guide as it changes with more or less water or with warmer or colder water over the ammonia condenser. It is true too low a head pressure is an indication that the charge is too small. There may be a shortage with serious effects on the output of the plant, without lowering the head pressure.

This is the case when not enough ammonia is in the system to maintain a permanent liquid seal in the ammonia receiver. Under this condition ammonia gas under head pressure will pass the expansion valve with the liquid ammonia. This gas will absorb no heat in the freezing system in expanding to the lower pressure, therefore the power used in raising it to the head pressure is a total loss.

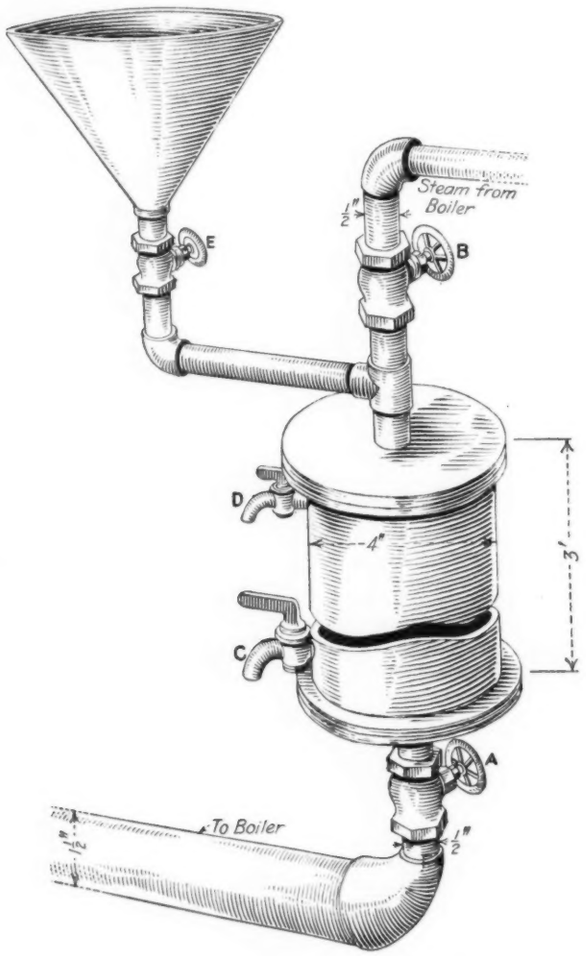
The best protection against mistakes in charging a refrigeration system is a glass gage or try-cocks on the ammonia receiver which will show the liquid level in the receiver.

FRED. KAISER.

Lansdale, Penn.

Boiler-Compound Feeder

The illustration shows a boiler-compound feeder that I have found easy to make and satisfactory. It operates by the condensation of the steam and is made up of ordinary pipe and fittings that require no description. The condenser pipe leading from the dome or steam space should be about 6 ft. above the water level in the boiler



FEEDER MADE OF ORDINARY PIPE FITTINGS

to produce a working head. To fill, close valves *A* and *B*, open drain and air cocks *C* and *D*, close the drain cock *C* and fill by means of the funnel through valve *E*. When full, close the air cock *D* and valve *E*, open valves *B* and *A*. The rate of feed is regulated by the valve *A*.

Brooklyn, N. Y. WILLIAM FORRAY.

The Unreliability of Fuses on Large Motor Circuits

In the Nov. 13 issue of *Power* H. Wilson states, in his article on "The Unreliability of Fuses on Large Motor Circuits," that large fuses do not act promptly on overload.

He mentions fuses of 1000-amp. capacity, but I take it that by large fuses are meant those in excess of 600 amp., this capacity being the maximum specified and approved by the National Electrical Code for inclosed fuses. Experience indicates that fuses of much smaller capacity are also unreliable. The time element of any fuse is variable, due to and intimately dependent upon so many factors met with in practice that it is sometimes difficult to approximate the ratings as specified in the code for any particular class of fuse, whether open-link or inclosed.

For instance, it was proved by experiment upon inclosed fuses located in a tightly closed cabinet, free from circulating air currents and connected to small lugs and cables, so that radiation and conduction of heat away was materially reduced, that they blew at an average of 80 per cent. below their rated capacity. The same-sized fuses, located in an open room of moderate temperature with good air circulation and connected to lugs and cables of large mass, blew at an average of 50 per cent. above the normal full-load rating of the fuse.

For the last few years there have been many motor installations of small sizes as low as 5 hp., both alternating- and direct-current types, where the protection on the individual motor circuits were inverse-time-elements circuit-breakers, no fuses being used. Local underwriters' bureaus in various states have approved this practice.

The writer has placed in service in New York State alone within the last five years, more than one thousand horsepower of small-sized motors, where the individual motor circuits have been protected by circuit-breakers exclusively, with satisfactory results.

It may appear at first glance that when the cost of the circuit-breaker is 50 per cent. of the motor cost, its use would be prohibitive. However, where continuity of service is paramount and the nature of the work is such that an interruption in the process means a defective product, it may safely be stated that the installation of circuit-breakers in place of fuses is a good investment.

MATHEW KING.

New York, N. Y.

Telescopic Oilers Now Approved

In the issue of Apr. 3, page, 463, I wrote telling of a disappointing experience with telescopic oilers for crosshead pins, which brought forth quite a lengthy discussion, chiefly in favor of their use.

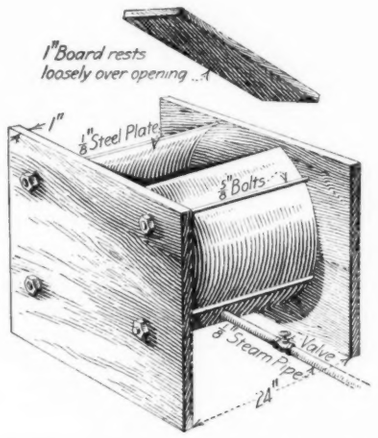
The discussion has proved beneficial to me as I have now a telescopic oiler which will feed a continuous stream of oil to the crosshead pins without any waste whatever. I am so well pleased with it that I feel it would be wrong not to correct any prejudice I may have created against their use.

J. B. WALKER.

Ninety Six, S. C.

A Home-Made Overalls Washing Machine

The illustration shows a home-made washing machine that is useful for washing overalls and other greasy clothes. Steam entering at the bottom causes a whirling motion that throws grease out beneath the lid, and it also goes out with the wasted water at the bottom. Anything put into it falls in front of the steam jet and the



WASHING MACHINE FOR THE POWER PLANT

force of the steam sends it spinning around the curved side of the washer until it falls on the jet again and gets another kick.

The amount of steam used is small, but its heat, in combination with the rotary motion, does the business effectively. F. D. BUFFUM.

Pittsburgh, Penn.

Regulating Fuel-Oil Burners

The following is offered as an addition to F. Drynan's article on the regulation of fuel-oil burners in the issue of Oct. 30, page 599, regarding the advantages of the oil-pressure method of regulation, and it would be well to emphasize the fact that the control should be by observing the fire itself.

In the operation of plants where the load is variable, constant attention must be paid to the proper regulation of the burners, for it is at this point that the direct control of the fire is best maintained. Most burners have a needle valve for controlling the flow of oil and a globe valve to regulate the atomizing agent, and these two valves must be set so as to admit each in the right proportion. To properly regulate the fire, it is necessary to observe the flame as it leaves the burners.

The needle valve controlling the oil supply is first set at what has been determined by practice to be the desired amount, but if the flame shows some smoke emerging from the tip, the atomizer valve is regulated gradually until this haze disappears, leaving a "red flame." With the fire in this condition one may feel assured that proper and economical combustion is taking place.

To relieve the necessity of constant attention at the burners several methods have been employed to regulate the fire, the majority of which embody the principle of allowing the boiler pressure to act upon the pump governor in such a manner as to increase or decrease the oil pressure at the burners. With this system there is a tendency to neglect the atomizer valve, setting it to suit the average load and allowing it to remain in this position regardless of variations in load, with the result that a bad "mixture" is formed at the burner, producing a higher fuel bill and a smoking stack. The proper adjustment of the two valves in relation with each other cannot be too strongly urged.

Milwaukee, Wis. EDWARD M. WALKER.

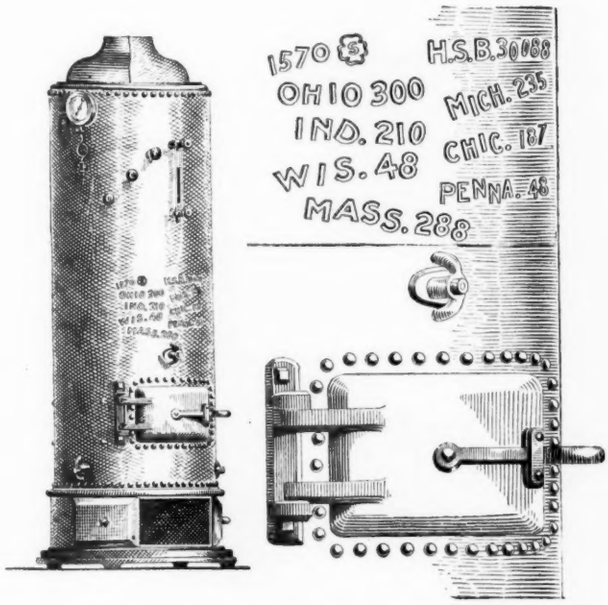
Sucking from a Condenser

W. H. Nostan, on page 740 of *Power* for Nov. 27, says that "the operator shut down the engine and the oiler shut down the condenser without shutting the valve controlling the water supply. Of course, the engine sucked up a cylinderful, and when the piston came back there was a bang." Will Mr. Nostan please show a sketch of this arrangement and indicate how the engine could suck a cylinderful of water from the condenser? RALPH BAER.

Pittsburgh, Penn.

One Official Boiler Stamp for All Boilers

The illustration represents the front of a vertical tubular boiler purchased by a contractor in the State of Pennsylvania. He desired a boiler that he could use in different states on contract work. Observe the num-



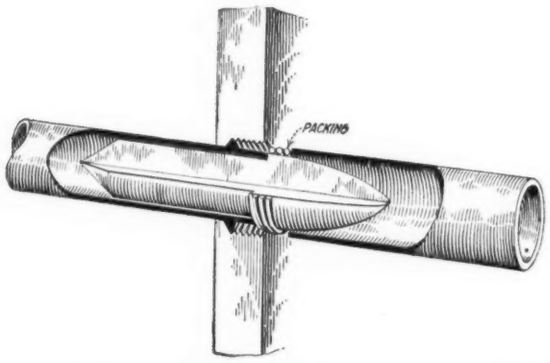
WHY NOT HAVE ONE OFFICIAL STAMP?

ber of stamps. Why not have one official stamp (the A. S. M. E.) to serve for all? It will come eventually; why not now? Surely, a uniform boiler law is advisable. J. A. SNYDER.

Pittsburgh, Penn.

Packing Condenser Tubes

It is easy to pack condenser tubes with a tool made as shown in the illustration. The smaller diameter is a neat fit in the tube, and the shoulder is the thickness of the tube wall, therefore the larger diameter is equal to that of the outside of the tube, and is slightly tapered



GUIDE FOR PACKING AROUND CONDENSER TUBES

toward the end so that the packing will draw up snug around it as it is forced forward. Place the tool in the tube with the shoulder resting against the end of tube, place the packing on the conical part of tool next to stuffing-box, then with a short piece of pipe of the right size over the end of the tool, drive the packing into the stuffing-box with a hammer.

Montesano, Wash. EDWARD M. KEYS, JR.

Noiseless Pipe Hangers

In the article about pipe hangers, by Mr. Cohen, page 686 in the issue of Nov. 20, I find no mention of a vibrationless or noiseless hanger so necessary in hotels or office buildings. This feature can easily be added to any of his hangers by the introduction of a few links of chain somewhere between the point of support and the pipe. This I have done in a number of instances with satisfactory results. G. B. COMFORT.

Philadelphia, Penn.

Economies Difficult To Introduce

The suggestions made by the New England Coal Committee referred to in the issue of Sept. 18, page 396, are interesting, but I believe this committee should also have recommended to plant managers that they look after the draft in their boilers, thereby reducing the amount of coal wasted in heating the outside air. I hope, because this committee is composed almost entirely of managers and presidents of companies using fuel, their recommendations will bring home to the plant managers of the entire country the almost universal disregard for efficiency in the boiler plant.

As an example of what some are up against, I quote in part a letter from the manager of a plant in the South:

"I hope you will not think that I am unmindful of your suggestions or discourteous, but I have not yet ucceeded in convincing 'the powers that be' of my ability to save as much as you persuasive fellows say we can. In other words, they are from Missouri, and I must convince them. They courteously listen as I earnestly explain, but there are always interruptions, and right now we are in the midst of some serious troubles and a bond issue to build another plant is on our hands. When I can, I will again take up this matter and hope to write you something interesting then."

This is an example of a manager who is held back by his executive board, and the pity of it is that this is not an exception but on the contrary, I believe, the rule. HENRY J. MALOCHEE.

New Orleans, La.

Charts for Recording Instruments

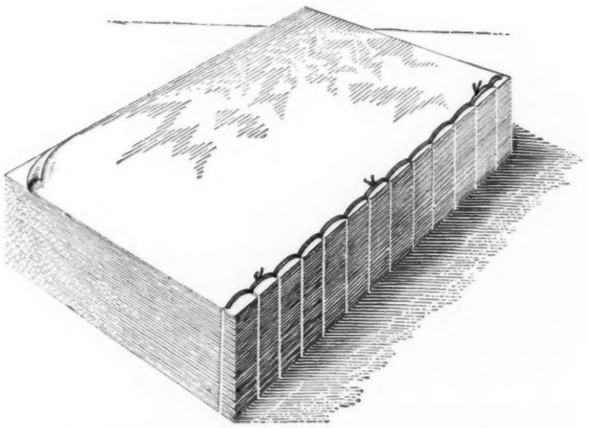
Mr. Wygod's method of using blank charts as described in the issue of Nov. 13, page 673, is all right for daily reference, but when the charts are filed away, on a rod as they often are, the one to be referred to must be taken off as well as all those above it in order to place it on the ruled chart, while a complete chart need not be removed from the rod. W. H. NOSTAN.

Philadelphia, Penn.

Binder for Periodicals

I have developed a way of binding my copies of *Power* that makes a "dandy" book. Take out all the advertising pages after removing the metal binding wires, even the edges and clamp the remaining leaves in a vise with the backs up, and with a hacksaw saw down through them to the depth of about ½ in. at intervals of about one inch. Use heavy cord or small wire and lace it back and forth through the saw cuts until strong enough to keep the pages from pulling out when the book is opened.

I bind each complete volume of *Power*, that is from January to June inclusive, in one book. The table of contents can be bound in with the reading matter in



MAGAZINES BOUND TOGETHER TO PRESERVE

regular order and at the end of the volume the complete index, so that an article may easily be found.

For a cover, a sheet of strong wrapping paper glued to the back and over the edges just enough to cover the binding cords may be used; or if a stronger cover is wanted, such as I use, take a piece of muslin, and cover two pieces of heavy pasteboard the size of the book and fasten this cover on by pasting a piece of muslin on the edge of the book along the edge over the binding and extend about an inch on the paste board covers. D. R. HIBBS.

New York City.

Inquiries of General Interest

Feeding Overheated Cast-Iron Low-Pressure Boiler—If water was lost from a cast-iron low-pressure boiler and it became overheated, would the boiler be injured by letting cold water into it? C. E.

If water were let into the boiler before it became cool, it would be injured and probably cracked from unequal contraction of the material due to sudden cooling.

Concrete Hot-Water Pressure Tank—Could a tank be constructed of concrete for holding hot water under a pressure of 100 lb. per sq.in.? F. C.

A pressure tank of reinforced-concrete construction might be made strong enough to withstand 100 lb. per sq.in. cold-water test pressure, but it would be impractical for holding hot water or steam at that pressure on account of danger from cracks likely to be developed in setting and by changes of temperature.

Girth Seams of Horizontal Return-Tubular Boilers—For the girth seams of a horizontal return-tubular boiler, what allowance is to be made for reduction of cross-sectional area of the boiler from the presence of the tubes? W. B. G.

Paragraph 184 of the A. S. M. E. Boiler Code provides that when 50 per cent. or more of the cross-sectional area of the boiler is occupied by tubes and through stays, the strength of the circumferential joints in the shell shall be at least 35 per cent. of that required for the longitudinal joints. The N. Y. Code also requires the shearing strength of the rivets to be not less than 50 per cent. of the full strength of the plate corresponding to the thickness at the joint.

Charging Elevators to Light, Heat and Power—In expense accounts of buildings provided with an isolated plant, is it customary to include the cost of labor, repairs, supplies and maintenance of elevators in the general account of light, heat and power? D. M. B.

In well-regulated establishments such a general account is assumed to include only debits and credits on account of specific service of light, heat and power, considered as power-plant products ascertainable from switchboard or other measuring instruments. Excepting items of electric current or shafting power furnished by the power plant, any entries pertaining to elevators would be as foreign to the title of the account, "light, heat and power," as items pertaining to machinery used for producing articles of manufacture.

Pressure and Superheat for Increase of Temperature—If a closed boiler or superheater is filled with dry-saturated steam at a pressure of 165 lb. absolute, without the presence of water, and by addition of heat the temperature is increased 500 deg. F., what would be the pressure and the degree of superheat? W. J. L.

Initially, the steam as dry-saturated steam at 165 lb. absolute would have a temperature of 366 deg. F. and a volume of 2.753 cu.ft. per lb. At the new temperature of 366 + 500 = 866 deg. F., there would be the same weight and density of steam present, and by inspection and interpolation of Marks and Davis Steam Tables it may be found that superheated steam having a volume of 2.753 cu.ft. per lb. and temperature of 866 deg. F. would be at a pressure of about 292 lb. absolute. The temperature of dry-saturated steam at this pressure is 415 deg. F., and with the temperature at 866 deg. F. there would be 866 — 415 = 451 degrees of superheat.

Rating Size of Water-Tube Boiler—Knowing the dimensions and number of tubes, drums and headers of a water-tube boiler, how can the horsepower rating of the boiler be determined on the basis of 10 sq.ft. of surface per horsepower? W. A. H.

The horsepower rating is to be based upon the total number of square feet of tube, drum or header surface of the boiler that is exposed to heat from the products of combustion with water on the opposite side of the material, allowing 10 sq.ft. of such heating surface per horsepower. The square feet of heating surface of a tube will be its diameter in inches multiplied by 3.1416, and by the number of inches of length exposed to the products of combustion below the water line of the boiler, divided by 144.

To find the heating surface of a drum, take the product of the diameter in inches multiplied by 3.1416, by the length of the drum in inches and by the fractional part of the length and the fractional part of the circumference of the drum that are exposed to the products of combustion below the water line of the boiler; deduct the cross-sectional area in square inches of all tube or other drum connections that are exposed to the products of combustion below the water line. The remainder will be the heating surface of the drum in square inches, and this divided by 144 will be the heating surface of the drum in square feet. The square feet of heating surface of a header will be the surface in square inches below the water line that is exposed to the products of combustion less the united area of hollow stay-bolts, tubes or other connections to that surface, all taken in square inches and divided by 144. The total number of square feet of heating surface so found divided by 10 will be the rated horsepower size of the boiler.

Steam Required for Operation of Return Trap—What boiler horsepower is required for operation of a gravity return trap to return 450 gallons of water per hour at a temperature of 235 deg. F., to a boiler that carries 100-lb. gage pressure? R. C.

It is assumed that the trap operates by displacing the return water with an equal volume of steam, and that after the displacement is performed, the steam thus employed is discharged as waste. Allowing 7⅓ gallons per cubic foot, the steam discharged would amount to 450 ÷ 7⅓ = 61.36 cu.ft. per hour. The density of steam at 100 lb. gage, or 115 lb. absolute, is 0.2577 lb. per cu.ft., and for displacing the water there would be supplied and discharged 61.36 × 0.2577 = 15.81 lb. of steam per hour. The total heat of the steam above 32 deg. F. would be 1188.8 B.t.u. per lb. and, assuming that it is generated from 235 deg. F., the heat supplied by the boiler for generation of this steam would be 15.81 × (1188.8 + 32 — 235) = 15,585.5 B.t.u. per hour.

Another loss of heat would be from radiation. Assuming 25 sq.ft. of surface and an average difference of temperature of 200 deg. F. and loss of 3 B.t.u. per square foot per hour per degree difference of temperature, the loss from radiation of heat would amount to 25 × 200 × 3 = 15,000 B.t.u. per hour.

This, together with the loss from discharge of steam, would be 15,585.5 + 15,000 = 30,585.5 B.t.u. per hour. As a boiler horsepower is equivalent to evaporation of 34.5 lb. of water per hour from and at 212 deg. F., or 34.5 × 970.4 B.t.u. = 33,479 B.t.u. per hour, the loss of heat from discharge and condensation of steam under the conditions assumed would be equivalent to $\frac{30{,}585.5}{33{,}479}$, or about 0.91, of 1 boiler horsepower. This does not include any loss of steam from leakage or any waste from discharge excepting to completely empty the trap of steam once for each charge of return water.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Production of Electricity by Steam Power

By ALEXANDER DOW
President, Detroit Edison Company

Abstract from a lecture delivered before the Thirty-Second General Meeting of the American Electrochemical Society held in Pittsburgh, Penn., Oct. 3 to 6, in which the author outlines the design of a power plant for the efficient generation of electricity from steam power.

IN 1894 I found myself called upon to design a plant for a street-lighting load, a matter of 2000 hp.; four or five units were used; at night a steady light for 4000 hours per year, shut down at daylight, and a trifling load all day. I deliberately selected a steam engine of 160 or 170 lb., practically a fixed cutout, although there was a governor of a sort. The occasion of a day load, which ran from 150 down to 75 hp., was met by the expedient of letting the steam pressure run from 160 to 170 lb. on the boilers down as low as it would go before doing any firing. The result was, it reduced the coal fired to 4 lb. per kilowatt-hour, which is equivalent to 2.5 lb. per indicated horsepower.

In 1902 I had the nerve to buy three 2000-kw. vertical-turbine alternators. These were put in operation in 1904 and remained in service until 1910; they were then displaced by better machines. These vertical-shaft machines ran on a film of high-pressure water or oil, and what would happen if one of these rotors with its 30, 40 or 50 tons of mass came down on the step bearing through the cutting off of the water or oil supply was always an interesting speculation. When it did happen, it was seen to be nothing serious. I do not recall the wrecking of one of these machines, due essentially to the rotor coming down on the step. I do recall one instance when the engineer in charge deliberately let the two surfaces of the step bearings come together for a fraction of a second to true up the surfaces. The remedy has been applied to a 14,000-kw. machine. The procedure is to turn off the water for just an instant, letting the revolving element down on the step bearing for a fraction of a second; then lift it again by admitting the water.

Large Boilers Safe and Feasible

In 1908 I came to the conclusion that a larger boiler would be perfectly safe and feasible, that a very large furnace was desirable for burning bituminous coal, and that stokers should have certain characteristics; and I was able to get financial support to build a power house designed for 56,000 kw., in which the boilers were of that type.

In 1912 two of these boilers were tested by Dr. Jacobus, and the results of these tests are in textbooks now. They established the very great importance of the correct adjustment of furnace and stoker as a part of the furnace, to the proposed fuel and work. They also decided that the efficiency curve of the boiler and furnace together is a very flat curve; that a range, in this instance, of 40 to 200 per cent. of the normal rating of the boiler was entirely practicable. These limits have not been much exceeded.

In 1914 and 1915 came the Conners' Creek power house, which represented the best I knew, and of which I shall speak tonight.

Fuel cost is one of the figures on which comparisons can be made, and fuel cost must be expressed in heat units to meet the comparison. These show year in and year out an approximation of 20,000 heat units per kilowatt, with periods below and periods above. They are the best that can be done with the limitations of the Conners' Creek plant.

The reduction of losses by radiation from the boilers proper is so extreme that the boiler room must be heated for the firemen. The turbines are essentially 12 lb. per kw.-hr. machines, and are habitually operated at their best point, about 11.5 lb. on test conditions, but we do not rate them at that.

The particularly interesting features here are the auxiliaries, the arrangement made for getting the most out of the auxiliaries—and therein lies what might be called "Chapter 1 of Instruction."

Heat Balance—You should not throw heat overboard beyond what you can save. The loss overboard in the condensing water is the big thing. It is the hopeless proposition today. Something like 0.8 of the heat units are lost in the condensing system. All other losses, radiation losses from boilers and engines, are minor in comparison. A hot boiler room is bad engineering—to be hot in the summer time is an offense to the men, and to be hot in the winter means that all outdoors is being warmed through the windows and the walls and the roof of the plant.

Power for Driving the Auxiliaries

In the Conners' Creek plant, which, as far as I am aware, was not taken from any other design, a separate electric generator of comparatively small size is used to supply power for driving the auxiliaries; the exhaust from the turbo-generator goes to heat the feed water to an economical temperature. That economical temperature being settled, you get out of the steam which goes to supply the auxiliaries all the power and likewise all the heat; and the auxiliaries have the great convenience of the electric drive. The feed pumps are also motor-driven, with a steam-driven feed pump to meet occasional conditions. All steam drive for auxiliaries must be wrong, and all electric drive usually is wrong. The correct choice lies between the two.

In this plant there are no economizers, however; that is a commercial proposition. The use of economizers would unquestionably save 4 per cent. of the heat units; and commercially, under the conditions of coal costs as they were two or three years ago, it would not pay. If coal stays at the present ordained figure—not to speak of the actual figures we are paying—economizers will be warranted.

If put in, the economizer would better the economy 4 per cent. The turbines could be replaced by machines 4 or 5 per cent. more efficient, and with the heat balance by betterments we can see, it would pick up 4 or 5 per cent. more. That is to say, we could reduce the present 20,000 heat units per kw.-hr. to 19,000, or thereabout. That is an entirely practicable figure at present, without going into new design. There are certain reasons why a lower design could be obtained, and they are commercial, such as load factor.

Load Factor of Different Loads

You gentlemen are in the habit of telling us you have 100 per cent. load factor; 90 per cent. is "going strong," and 80 is more frequent. On the other hand, a mixed service is doing well if it shows 40 per cent. Any central station with a load factor above 40 per cent. is doing well indeed—below that is common. The load factor of resident lighting is of the order of 8 per cent.; that is, resident service uses the equipment about eight-hundredths of the time that electrochemical service might.

The capital cost of the Conners' Creek plant, on the first units, was between $50 and $60 per kw. If you buy land for 300,000 kw., and you prorate that over the original investment or installation, and you put in railroad tracks, and dike out lakes, and put in all the facilities and offices, all these cause the unit cost to go high; therefore the variation is between $50 or $60; but the crazy price of the last few years would make the cost go up between $90 and $110 per kilowatt. One hundred and eighty per cent. is just about the cost of construction as compared to the cost considered normal before the world went crazy.

Communities which in the past have favored the manufacturer with a low estimate on the plant for taxation purposes will assess a public-service corporation up to the eyes; and let me say that taxes in the last year required us to earn $1600 a day, Sundays included.

The first thing to consider is how the location may effect the power plant; and that leads into those engineering problems I wish to put to you. With electrochemical industries, of course, you must consider your raw materials and your market. You must have good shipping points, fairly good labor conditions, etc. These conditions will have a large influence in determining the location.

Fuel cost will be one of the most important things to consider. In connection with fuel you must consider the certainty of the supply—that it will not be interrupted.

The quantity of water used by a big steam plant is something you do not conceive. A plant of 100,000-kw. capacity operating at 50-per cent. load factor will require to pass through its condensers approximately the same amount of water as will be used by mixed residential, industrial and commercial communities having a population of 750,000 people. In other words, the power plants of the Detroit Edison Co. takes up from the river heat 10 or 15 deg., and rejects to the river again more water than is pumped for the whole community. Therefore, the water-supply is the next thing to consider after a good fuel supply. You must locate on navigable rivers or streams, or on the Great Lakes. Cooling towers are devices you must foreswear if you are working for maximum efficiency.

In the design of the intake and the outflow tunnels of many of the plants I know, the mistake has been made in making them too small. In the Conners' Creek plant the canals leading the water to and from the plant are of a size that would almost permit running a railroad train through them.

Location of Power Plants

If you locate in a place where people consider the outer appearance, you must think of an architect. I can think of three power houses where the outside appearance is a credit to the public spirit of the board of directors, while the inside is a libel upon the architect. Foundation will run to $5 per kilowatt when you locate in a marsh with rock 100 or 150 ft. down, and you must pile or go down to that rock; or if you locate on the Ohio River, where you have 70 ft. of rise and fall, there you have a serious problem.

What is the possibility of higher pressures? This is a question about material only—I speak of pressures from 300 to 400 lb. If you get to a consideration of the fact that you are working with high velocity in the turbines, with pressures of 300 to 400 lb. per sq.in. and with temperatures of 700 deg. F.; if you consider that these pressures and velocities of your turbines—and the heat and the temperatures are all present—you will realize that the selection and production of those materials is a problem. Commercial reasons are likely to keep us under 300-lb. steam pressure, and under 700-deg. F. temperature, for total steam temperature. The history of the things that have been tried to get beyond that stage is unending. Some of us are using high-carbon boiler tubes because we punish them too much already. The stories of the castings, and shrink-fits that did not stay shrunk, and corrosion, etc., are endless.

The gas engine has its place. At present the large steam turbine has it beaten. With free gas or natural gas the gas engine has its merits.

Pulverized coal must be considered in any new design. It is first-class now in locomotives, because of the impossibility of firing by hand the present big machines. There is a better control of air mixture; you cut off your fuel, and that is the end of it. The whole question of pulverized coal turns upon the point that it may make useful coal, which, with stokers of the present time, are not useful. This may tend to reduce total power costs.

One very important point is the value of high furnaces. In general, a high furnace will burn low-volatile coal, whereas the low furnace will not burn the high-volatile coal, because the flaming gases are in the tube and combustion there is not complete. High furnaces mean high brick walls and water-cooling of the walls. High brick walls, unless built on honor and with a keen appreciation of expansion stresses, are a failure and a source of trouble. The man who builds high concave walls which are slightly dished so that the stresses due to the heat on the inside are taken care of, who rubs each brick down to its seat, has got to be as honest as the old monk cathedral builders in the Middle Ages. This is a job for an artist and not for a workman.

Overstoking is another trouble. We sometimes drive some of ours 300 per cent. We do that because the load factor is so bad that it pays to drive the furnaces and boilers to the extreme limit during a short period rather than put in twice as much furnace and boiler capacity and work it more reasonably. There is a limit—a compromise—that in these days must be based upon experience.

Turbine troubles exist, of course. Turbines, most of them, are fine machines, so to speak; treat them right and they will treat you properly, and if you do not, they will have hysterics or the mechanical equivalent thereof. There are a few bad turbines. If you put 200 tons of turbines on a foundation, it is well, after six months' time, to examine that foundation to see if it has settled. A well-made piece of machinery, such as a turbine, requires a little imagination on the part of those having it in charge, to know what is going on, on the inside.

Steam-Turbine Troubles

One of our small turbines, a well-built machine, for some cause unknown, lifted itself out of its bearing, waltzed across the floor and unfortunately killed a man. That was a small machine. Machine No. 2 came through properly. The man who was intending to stop the machine shut off the exhaust before closing the throttle. With a development of 250 lb. pressure in the exhaust, you can imagine just what happened.

No. 3, a 20,000-kw. unit, started to vibrate, and was shut down before anything happened. On opening the machine, it was found that two disks had developed cracks. One had gone through the rim and was starting peripherally. In this particular machine all that happened was, the blades had pulled out and were hitting the casing. The machine might have run some time before developing trouble. We cut off the rows of blades, and a machine that previously did 22,000 kw. now does 18,000 kw. with two disk rows out. It is a 13.5-lb. machine instead of a 11.5. Certain troubles are possibly due to mishandling, as well as to error in machine design. We have ceased to call them bad names, and we respect their requirements.

No Great Change in the Art

It is not good to prophesy, but I know that some of you expect to hear from me whether I anticipate any great change in the art. I do not, just now. Dr. Lardner went on record as saying that no steamship could carry enough coal to make a voyage across the Atlantic. That was accepted in the 30's, while in the 40's there was a steamship line established. Therefore, all I can say is that there is not in sight any great change. Unless we can find the material to take us into higher temperatures, boiler efficiences—are 80 and 90 per cent., we need not expect much change there. The remaining losses are commercial, which cannot be saved profitably, and the losses necessary to the stack to give the necessary draft and combustion, also the big losses of heat thrown overboard in the condenser system—they seem to be inherent in steam. There may be a cycle produced which will solve all this.

The lecture was discussed by L. Addicks, member of the Naval Consulting Board, and F. A. Lidbury, works manager, Oldbury Electrochemical Company.

Mr. Addicks—I believe the day is past when we shall buy power from the central station, the electrochemical plant being away from the city, the power plant being where property is expensive, and almost everything against it. But I think the possibility of building a steam plant for the special use of electrochemistry is the next idea. There you get away from all question of governmental control, and you can build a plant without regard to control, light, heat or any other losses.

I looked into prices a short time ago, and the conclusion I reached was that if you get coal for $1.25 a ton, for good

soft coal at the mouth of the mine, and excluding the interest on the investment, you could probably generate a horsepower year for $15. Now, there you can get to about where the rates at Niagara Falls are. I do not think the cost of the water-power plant is going up, as the steam plant will, as the main cost in water power is a concrete dam which is easily constructed. There is still hope that the water-power phase will show better cost than the steam plant is doing.

Mr. Lidbury—In an address and discussion about 18 months ago in Washington, contrary to all that had ever gone uncontradicted, Mr. Addicks took the view that we had better stop speaking of the water powers that existed in this country, and turn our attention to steam, because, as he then pointed out, it was according to his views, going to be as economical to generate steam as to use water power. Taking the figures Mr. Addicks gave at their face value, a number of us decided to look into the matter and see what could be done. The result of this detailed conference we had with Mr. Dow at Niagara Falls was, I am sorry to say, that most of us lost interest in steam power under present conditions. It seemed to be a matter of general conclusion, that if we could go back to pre-war conditions the thing would not only be worthy of general consideration, but of serious detail consideration.

What we see today is the continuation of the process we have been watching going on for a number of years in an increasing degree, and will continue as far as we can see at present, and that is the expatriation of industries which exist primarily for the needs of this country.

You all heard Mr. Randall's paper this morning, and about the waterfalls at Shawinigan; and you may have heard of people transferring from Niagara Falls, U. S. A., to Niagara Falls across the line, owing to the activities of the commission and people developing power in that country, so that constantly the expatriated group at Niagara Falls is moving toward Shawinigan, which seems to be the best territory.

However, there is a national aspect to this matter. In the broad point of view it is very doubtful to what extent this country should permit the migration of industries which are as fundamental to its life as any other that can be mentioned. We have got to let these industries go as far as their development goes, or we have got to treat the matter politically, and decide they must be kept in the country, at whatever price steam power might permit them to produce their goods, and impose a tariff sufficiently heavy to be prohibitive. Or, the most sensible course, to permit and to insist upon and to enforce the thoroughgoing utilization of our natural water-power resources which could solve this whole question inside of two or three years.

Today this country is face to face with an alarming condition with respect to its productive power, for a tremendous number of articles that are fundamental necessities for warfare. We are going to have a demonstration of the policy which this country has developed in regard to water-power legislation, and the only hope we can express is that when matters do come to a sufficiently clear indication of the mess we are in, we will put ourselves in such a position that the same thing cannot occur again.

Open-Grate Fires Wasteful

By Van H. Manning
Director of the Bureau of Mines, Department of the Interior

The chilly days of autumn call attention to the proper use of the grate fire by those who will try to help the country save coal. When the need of using fuel economically is as strong as it is now, we can say, twisting our words a bit, that the proper way to use the grate is to use it not at all. If we look at the open grate as merely a heating device, and know how small a proportion of the total heat in the fuel enters the room to be warmed, we must regard it as probably the most inefficient of all the inefficient devices used in heating a house. The cheer and companionship of an open-grate fire must not be charged against the heating bill, but to some other account.

Efficiency is always a ratio or fraction, and is what you get out compared with what you put in. Into the grate one puts fuel that has the ability to produce a large amount of heat, but the useful heat obtained is relatively small. Most of the heat in the fuel goes racing up the chimney, in company with a large amount of air from the room, this air being replaced by cold air drawn in through cracks and crannies in the windward side of the house. As a device for drawing in cold air a grate is excellent, but it furnishes much more ventilation than is needed. Much less fuel, properly burned in a stove, would warm the house better.

The grate fire is such a cheerful, lively member of the household on chilly mornings and evenings that it is loved in spite of its spendthrift ways. The present fuel situation, however, suggests that the grate should be filled with coal much less often than in the past. It should be used when only a little heat is needed for a short time. It should be fed on waste wood as much as possible. The flickering flames of a smaller fire may be made sufficient to excite the fancy rather than the scorch and the big roar of too full a fireplace. When steady heat is needed, economy suggests doing without the cheer and running the more sedate stove.

Enlisted Men's Insurance Law

By W. G. McAdoo
The Secretary of the Treasury, Washington

To the Officers and Enlisted Men and Women of the Army and Navy of the United States and Their Relatives:

The Secretary of the Treasury, through the Bureau of War Risk Insurance, has been charged with the administration of the War Insurance Law enacted by the Congress as a measure of justice to the men and women who have been called to give their lives, if need be, in the service of their country.

I wish to acquaint you with the benefits and privileges which your Government has placed at your disposal. It is essential that you and your families at home should know of your and their rights under this law in order that full advantage may be taken of them.

To care for the wife and children of the enlisted man during his service, the War Insurance Law compels him to contribute up to one-half of his pay for their support. The Government, on application, will generously add to this an allowance of from $5 to $50 a month, according to the size of the family. Moreover, if the enlisted man will make some further provision himself for a dependent parent, brother, sister or grandchild, they may be included in the Government allowance.

If, as a result of injuries incurred or disease contracted in the line of duty, an officer or enlisted man or an Army or Navy Nurse should be disabled, provision is made for compensation of from $30 to $100 a month to him, and, should he die, compensation of from $20 to $75 a month will be paid to his wife, his child or his widowed mother.

In order, however, fully to protect each person and family, Congress has made it possible for every soldier, sailor, and nurse to obtain life and total-disability insurance. This insurance applies to injuries received while he or she is in the service or after he or she shall have left it.

Exposure to the extra dangers of war makes the cost of life insurance in private life-insurance companies prohibitive. It was, therefore, a plain duty and obligation for the Government to assume the risk of insuring hundreds of thousands of our soldiers and sailors who are making the supreme sacrifice. Under this law every soldier and sailor and nurse, commissioned and enlisted, and of any age, has the right, between now and Feb. 12, 1918, to take out life and total-disability insurance up to $10,000 at very low cost, with the Government without medical examination. This right is purely optional. The soldiers and sailors are not compelled to take insurance, but if they desire to exercise the right, they must do so before Feb. 12, 1918. The cost ranges from 65c. monthly, at the age of 21, to $1.20 monthly, at the age of 51, for each $1000 of insurance. This is a small charge on a man's pay—small in proportion to the benefits may bring. The premiums will be deducted

from his pay, if he desires, thus eliminating trouble on his part.

To provide adequate protection until Feb. 12, 1918, during the period when the soldiers and sailors are learning the details of this law, the Government automatically insures each man and woman, commissioned or enlisted in the military service of the United States. It pays the man $25 a month during total permanent disability; if he dies within 20 years, it pays the rest of 240 monthly installments of $25 each to his wife, child or widowed mother.

I desire to call the provisions of this just and generous law to the attention of our officers and enlisted men and women so that they may not be deprived of their rights through lack of knowledge. Full information may be obtained from the Bureau of War Risk Insurance of the Treasury Department, Washington, D. C. I earnestly urge that the officers of the Army and Navy give to the men under their command all possible aid in helping them to understand fully the benefits that this insurance may bring to their families and the small cost at which it may be obtained.

This is the greatest measure of protection ever offered to its fighting forces by any nation in the history of the world. It is not charity; it is simply justice to the enlisted men and women and to their loved ones at home, and each and every one of them should promptly take the benefits of this great law.

The American Society of Mechanical Engineers Meeting

The keynote of the thirty-eighth annual meeting of the American Society of Mechanical Engineers was war, and it was the largest and most enthusiastic meeting in the history of the society. The opening session was called to order in the auditorium of the Engineering Societies Building, in New York, on the evening of Tuesday, Dec. 4, by President Ira N. Hollis. Honorary membership was conferred upon Maj. Gen. George W. Goethals, and Hon. William H. Taft, former President of the United States, delivered a stirring address, "The Nation's Call to the Professional Man," the most illuminating, unpassionate and yet stirring statement of the causes which have induced the United States to take up arms which has yet been published. The addresses were followed by a reception to the president and president-elect, ex-President Taft and General Goethals being in the receiving line.

On Wednesday morning President Hollis delivered his address on "The Service of the Engineer to the Public in Times of Crisis," an able presentment of the relations and duties of the engineer to the community, especially in times like these. Our profession has long been classed as one concerned only with the application of science. It covers a very wide range, reaching on the one hand from invention and construction that affect the whole history of the race, and on the other hand to the little things that add only to convenience and comfort in our daily lives. . . . It is our task as engineers to assist in making the world safe against the forces that we have unloosened, so that the century may not close with a total failure of the civilization of the Christian races. . . . It is a curious thing that James Watt should have been prevented from practicing a trade that he learned in London by the trade guilds of Glasgow. By a strange irony he improved the steam engine and thereby let loose the forces of labor saving against the trade union, thus creating problems infinitely more difficult than anything connected with labor a century and a half ago. It is the psychological moment when all people, especially the engineers, should strike a good blow toward the education of men and women for service under the state, and for that kind of self-control and sacrifice that produces efficiency in a republic.

As part of the general publicity, we must dwell on saving for the war. Economy in food, fuel and clothing is the moral duty of everyone. One of the saddest sights in an American community is the organization of merchants to tell people to go on in their former mode of life and to buy. Carry this idea to its logical end and we shall lose the war. Prosperity has not come. All boosting of prices is blood money, and the men who are taking advantage of the country's need will be tainted all their lives. One of the most necessary distinctions in business is the priority of essential industries. All unessentials must go, and all excess profit must be saved for the success of the country in war.

Following President Hollis, Gano Dunn told what the engineering societies had contributed toward the national defense. Dr. Charles S. Howe spoke upon "Special Education in Time of War," emphasizing the necessity of continuing the education and preparation of engineers. C. E. Skinner spoke upon "Engineering Research." Dr. W. H. Jordan spoke on the agricultural problem, and Prof. L. P. Breckenridge upon the fuel problem. William P. Kennedy spoke upon "Motor Transportation," Maj. L. B. Moody upon "Army Transportation," Prof. W. F. Durand upon the "Aircraft Problem," and Leonard Metcalf on "The Solution of the Cantonment-Construction Problem."

Professor Breckenridge's Address

Of all these able and illuminating addresses, that most intimately connected with our problem was that of Professor Breckenridge upon the "Fuel Problem." The conservation of fuel, he said, is preëminently one of the engineer. Fuel is the basis of power engineering, and it is the duty of the engineer to control the forces of nature for the benefit of mankind. The true engineer abhors waste, be it food, fuel or labor. Coal is a universal necessity. At no time in our history has its importance been more clearly realized. The entire amount of coal mined in the United States, up to the date of the foundation of the American Society of Mechanical Engineers, was less than the increased production of the last ten years over the previous ten years. The coal bin of the United States is not full. It needs one hundred million tons to fill it. It looks as though we should not be able to produce this needed extra one hundred million tons. It will therefore be necessary to save at least fifty million. Let us build a bin for the coal of the United States, beginning at the corner of Fifth Ave. and 42nd St., proceed to the corner of the same avenue and 39th St., over to Sixth Ave. and back to 42nd St. This would make a bin of something like 1000 ft. on the side, and if it were to hold the year's supply of coal for the United States it would have to be 4½ miles high.

The chief drawback to increased production is the lack of capacity on the part of the railroads to take the coal away from the mines. The mines have no storage capacity. The best storage is in the mine itself, and the coal is best taken out only when there are cars ready to receive it. Thirty-five per cent. of the entire freight hauled by the American railroads is coal. Anything that can be saved, coal or otherwise, that has to be carried by the railroads, has a bearing upon the distribution problem. The necessity for saving reaches back into the necessity for using cars, locomotives, tracks and terminals for other purposes. The question of the use of coal divides itself into two heads—first, as to whether it should be used at all, and second, if it must be used, to see that it is used with the greatest economy. Here is the province of the engineer. Since the foundation of this society thirty-seven years ago, many distinguished members have made important inventions and contributions and researches, contributing to the economical burning of fuel, the generation of steam and of electricity. About 15 per cent. of the coal mined is used for household purposes and is handled by something like twenty million people. If they could be taught to use it most efficiently, perhaps 10 per cent. could be saved, but more could be saved if they were taught to use efficiently the heat made by it. It would be difficult to get at all of these people, and it can be done only by general publicity. On the other hand, 67 per cent. is used for making steam and is shoveled by probably not over a quarter of a million firemen. The handling of the coal is their especial task. They are readily get-at-able. A large percentage of the coal that they burn can be burned more efficiently, and their instruction and cooperation, and the insistence of their managers upon careful and efficient use, is one of the most promising sources of saving and one that can best be effected by the coöperation of engineers. As an evidence of what may be in sight for

us, Professor Breckenridge said that in France 264 lb. of coal a month is allowed for a family of four people, and the price is from $35 to $50 a ton. In Italy there is no coal. Charcoal is sold for $50 a ton, and last year one thousand square miles of timber were cut down to make the charcoal. In London a ton of coal a month is allowed for a seven-room house. We need not be surprised in the early future to see people who do not use coal economically deprived of the opportunity to get any coal.

The coal conservation of the country is in the hands of Fuel Administrator Dr. Garfield, who has designated Dr. Norris as his adviser with particular reference to coal. Dr. Norris looks largely to the coöperation of the Bureau of Mines for technical information upon this subject, and at the invitation of the Bureau the United Engineering Societies have named the following Committee of Consulting Engineers on Coal Conservation and Publicity to coöperate with the Bureau: O. P. Hood (secretary), chief mechanical engineer, Bureau of Mines, Washington, D. C.; L. P. Breckenridge (chairman), department of mechanical engineering, Sheffield Scientific School, Yale University, New Haven, Conn.; R. H. Fernald, department of mechanical engineering, University of Pennsylvania, Philadelphia, Penn.; C. R. Richards, director, Engineering Experiment Station, University of Illinois, Urbana, Ill.; C. L. Edgar, president, Edison Illuminating Co., 70 State St., Boston, Mass.; Carl Scholz, president, Coal Valley Mining Co., La Salle Street Station, Chicago, Ill. (for mail, 547 West Jackson Blvd., Chicago, Ill.); David M. Myers, 110 West 40th St., New York.

In addition, most of the states have coal administrators, many of whom have invited the coöperation of engineers, and this offers an excellent opportunity for engineers to be of service in this connection.

At 2:30 Wednesday afternoon the Power Plant Section met on the fifth floor. Considerable interest was shown in a paper by W. J. A. London on "A Commercial Analysis of the Small-Turbine Situation." This paper will appear later in *Power*. This was followed by "Preventable Waste of Coal in the United States," by David Moffat Myers, about which there was sufficient discussion to use up most of the remainder of the afternoon. Those taking a large part in the discussion were Walter N. Polakov, Prof. L. P. Breckenridge, Albert Carey and Norman Reinicker. Mr. Carey proposed immediate licensing of firemen by the Government. Edward N. Trump encouraged the wider adoption of bonuses to act as incentives for the firemen to fire economically. Professor Breckenridge talked in the same strain as mentioned previously in this respect, emphasizing the need of measures to effect saving of coal. Mr. Polakov favored priority of coal supply to those who use it most economically.

The smoker, Wednesday evening, was largely attended, the auditorium being packed to hear John R. Freeman's illustrated talk on his trip to the Orient with Dr. Brashear and Ambrose Swasey—"Baron" Swasey, as Mr. Freeman said the Orientals insisted on calling him.

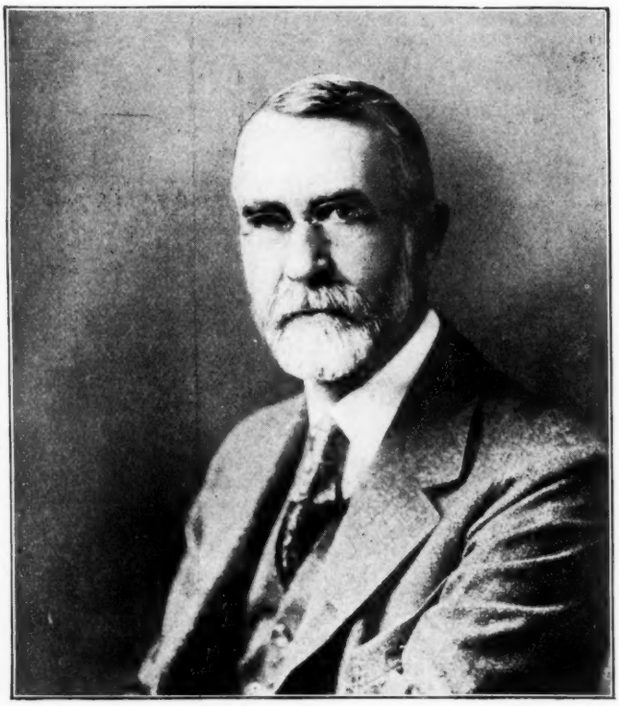
As *Power* goes to press, the meeting is still in progress. The registration on the first night had exceeded one thousand, and the meeting will in all probability be the record meeting of the society in point of attendance, notwithstanding the disturbed conditions of the country. The following officers have been elected for the coming year: President, Charles T. Main; vice presidents, Spencer Miller, Max Toltz and John Hunter; managers, Fred A. Geier, D. R. Yarnall and Fred N. Bushnell; treasurer, William H. Wiley.

The New President of the A.S.M.E.

Charles Thomas Main was born in Marblehead, Mass., on Feb. 16, 1856. He attended the public schools in that town and was graduated from the Massachusetts Institute of Technology with the degree of S.B. in the department of mechanical engineering. He remained at the institute as an assistant in the department of mechanical engineering for three years after graduation.

In the fall of 1879 he went to the Manchester Mills, Manchester, N. H., as draftsman. From there, on Jan. 1, 1881, he went to Lawrence, Mass., as engineer for the Lower Pacific Mills; in March, 1886, he was made assistant superintendent, and in July, 1887, superintendent of the mill, having in charge the engineering work also during the latter periods. During this period of eleven years he had charge of the reorganization and the rebuilding of a large portion of the aforementioned plant, and for something over five years had charge of its operation.

About this time Mr. Main decided that he preferred to follow engineering rather than administrative work and resigned his office at the Pacific Mills. After one year in Providence, R. I., spent in engineering and mill work, he formed an association with F. W. Dean and conducted a business under the name of Dean & Main, devoted largely in the early days to textile-mill work, but gradually broadening so as to include other industrial plants. This association existed from January, 1893, to January, 1907, when it was dissolved. Since that time he has conducted an engineering business under the name Charles T. Main.



CHARLES THOMAS MAIN

During the period from 1893 to the present time a large number of industrial plants have been designed and constructed under his direction and many others reorganized. The steam engineering for industrial plants developed into steam-power-plant work, and the water-power work into hydro-electric developments. Among the largest undertakings in the industrial plants are the Wood Worsted and Ayer Mills, in Lawrence, Mass., and in the hydro-electric work four developments for the Montana Power Co., aggregating about 280,000 hp. He has acted as consulting engineer on many projects and as expert witness or referee in many important cases.

He was elected to membership in the American Society of Mechanical Engineers in 1885 and has been a manager for three years. He is also a member of the American Society of Civil Engineers, the American Institute of Consulting Engineers, the Boston Society of Civil Engineers (past president) and of other technical societies; is president of the Engineers' Club of Boston and is serving his second term as term member of the Corporation of the Massachusetts Institute of Technology.

He has written several papers on engineering subjects, some of which have been presented at meetings of the society he now heads.

Mr. Main has been interested for many years in public affairs and has served in several municipal offices for the purpose of advancing the idea of good government and doing his share of public work.

Meeting of American Society of Refrigerating Engineers

The following is a brief report of the thirteenth annual meeting of the American Society of Refrigerating Engineers, Dec. 3, 4 and 5, at the Engineering Societies Building, New York City. The meeting opened Monday with President N. H. Hiller, president of the Carbondale Machine Co., in the chair. Tellers reported the election of Ezra Frick, president of the Frick company, Waynesboro, Penn., to the presidency of the society. Unfortunately, Mr. Frick did not reach New York until Wednesday morning. F. E. Matthews, New York, is the new vice president. On each day of the meeting a subscription luncheon at one dollar per plate was served in the meeting room.

The first paper was read by Harry Sloan, of the Vilter Manufacturing Co., Milwaukee, on "The Practical Side of the Low-Temperature Compression System." The paper referred to operating results at the new Ninth Street Terminal, Chicago, but owing to delay in construction of the plant and building, satisfactorily complete data were not available. Henry Torrance followed with discussion on Ammonia Condenser Data, which were vigorously attacked by Louis Block. The data presented by Mr. Torrance did not settle the much-discussed subject as to the merits of some particular makes of flooded condensers. F. N. Fairbanks, of Boston, reached an agreement with Mr. Block whereby a test might be made of the Block condenser at one of the plants of the Quincy Market Cold Storage and Warehouse Co., Boston, of which Mr. Fairbanks has charge. Next year, perhaps, some interesting, final and valuable information may be presented on this subject.

In the topical discussion on fore-cooling liquid ammonia between the receiver and the expansion valve, everybody agreed that in most plants it was desirable.

"Gas Formation in Ammonia Absorption Systems" was the subject of an informal talk by E. C. McKelvey, chemist, Bureau of Standards, Washington. There followed discussion on loss of ammonia in ice plants and the relative advantages of horizontal and vertical shell-type brine coolers. Other papers read were: "Treatment of Water for Raw-Water Ice Making," by M. F. Newman; "Most Economical Temperature Difference Between Liquefaction Period and Water Leaving Condenser"; "Purging Ammonia Condensers"; "Recent Studies in Heat Transmission," by Prof. A. J. Wood; "Defrosting Cooling Coils"; "Correct Submergence of Ice Cans in Freezing Tanks"; "Heat Balance of Ammonia Compression System," by J. H. H. Voss; "Synchronous vs. Slip Ring Motors for Refrigereating Machine Drive"; "Analysis of Can Ice Freezing System."

The dinner Tuesday evening was very well attended. Among the speakers were Howard Jenks, who spoke for Mr. Frick; Thomas Shipley, Theodore O. Vilter and Louis Block, Mr. Block making a very beautiful address on "Personal Service." President Hiller was toastmaster. Report of the papers will appear in a later issue.

Will Lecture on Fuel Conservation

Charles H. Bromley, associate editor of *Power*, will address the engineers of Greater New York on the subject of the "Fuel Situation and Fuel Economy," Corinthian Room, Terrace Garden, 155 East 58th St., 8 p.m., Saturday, Dec. 15. Lantern slides will be used. Mr. Bromley will review the coal-production conditions, the increased consumption by the industries, the rail and marine freight situation, important action by the Fuel Administration and how foreign governments are handling the coal situation. Following this Mr. Bromley will briefly present means by which coal may be conserved by firemen and engineers.

After the lecture the following engineers will present short papers telling of their firing methods and the results obtained: Norman King, Singer Building; Willis Lawrence, mechanical engineer, Interborough Rapid Transit Co.; Harry Langhan, chief engineer, Museum of Natural History; Patrick J. Cassidy, chief engineer, Churchill's; and Fred Johnson, chief engineer, McGraw-Hill Publishing Company.

The meeting will be open to all interested. It is under the direction of the New York State Educational Committee of the National Association of Stationary Engineers.

Personal

J. H. Pardee, president, and **J. P. Ripley,** railway engineer, of The J. G. White Management Corp., New York City, are visiting the Philippine Islands, making a general inspection of the Manila Electric Railroad and Light Co. and other interests in the Islands operated by the Management Corporation. They are expected to return to New York City about Jan. 15.

Obituary

Benjamin Murray Plumber, president of the Main Belting Co., of Philadelphia, died on Nov. 26, in his 87th year. He was born in Bethel, Maine. His early business activity took him to New York, Mexico and New Orleans, thence to England, where he spent 18 years in connection with American shipping. In 1881 he founded the Main Belting Co., which he has helped successfully to build up to its present well-known standard.

Engineering Affairs

The Baltimore (Md.) Section of the A. S. M. E. will hold a meeting at the Engineers' Club on Dec. 19.

The Philadelphia Section of the A. S. M. E. will hold a meeting on Jan. 22, at which Prof. William L. Cathcart will read a paper on "Our Navy and the War."

The Philadelphia Section of the A. S. M. E. will hold a joint meeting with the Franklin Institute on Dec. 11, at which Joseph A. Steinmetz will give a talk on "Offensive Against the Submarine."

The Providence (R. I.) Chemical Section of the A. S. M. E. will hold a meeting on Dec. 21. Jesse E. Gray, chief engineer of the Narragansett Electric Lighting Co. will read a paper on "From the Coal Pile to the Lamp."

Local No. 784, International Union of Steam and Operating Engineers, held its annual entertainment and ball at the New Star Casino, New York City, on Wednesday evening, Nov. 28. The hall was neatly decorated and there was the usual big attendance. An enjoyable vaudeville program preceded the dancing.

The American Institute of Electrical Engineers will hold its 335th meeting in the Engineering Societies Building, 33 West 39th St., New York, Dec. 14, 1917, at 8:15 p.m. Two papers will be presented at this meeting: "Magnetic-Flux Distribution in Annular-Steel Laminæ," by Dr. A. E. Kennelly and P. E. Alger, and "Phenomena Accompanying Transmission with Some Types of Star Transformer Connections—II," by L. N. Robinson. The latter paper is an amplification of Mr. Robinson's former paper, presented at the Panama-Pacific Convention of the A. I. E. E., published in the "Transactions," Vol. XXXIV, 1915, p. 2183.

International Union of Steam and Operating Engineers, Local No. 56, held its annual masque and civil ball on Saturday, Dec. 1, at Labor Lyceum, Willoughby Ave., Brooklyn, N. Y. The attendance was fully up to the standard of these events. A large percentage of the assemblage wore costumes, which were divided between the handsome, novel and unique. Valuable prizes were distributed among the masqueraders. Dancing was the principal feature of enjoyment. An innovation this year was the entertainment given in the new hall adjoining the ballroom. Altogether a pleasant night was spent. The officers of the association include R. H. Watts, president; Joseph Muntefering, vice president; F. C. Miller, recording secretary; N. C. Ames, corresponding secretary; H. Schneider, conductor; G. Schaefer, guard; H. Greve, treasurer; F. Rauscher, business agent.

Miscellaneous News

Immediate Coal to Essential Industries—The Fuel Administrator has sent to coal producers a list of consumers who are to receive coal in preference to others as they are engaged in industries vital to the war. This priority is not compulsory; but the request will be followed, it is believed, and is for a period of thirty days. The fuel administration has rejected a plan to cease shipments of coal to nonessential industries.

Electric-Sign Displays—Further instructions to State Fuel Administrators as to the regulation of electric display signs have been issued by the Fuel Administration. The new instructions were prompted by reports that the electric-sign order was not being closely obeyed in some cities. State administrators are warned that unless the spirit of the limitation order is strictly enforced, the Fuel Administration will withdraw all exceptions to the order and prohibit the illumination of all electric signs except between 7:45 and 11:00 o'clock in the evening.

Proposed Increase in Power Rate—The Metropolitan Edison Co., of Reading, Penn., has filed with the Public Service Commission at Harrisburg, Penn., supplements to its present tariff schedules, providing for an increase to power customers to be regulated by the prevailing prices of coal. The new rates, if approved, will become effective Dec. 16, 1917. The coal clause provides for an increase of about one mill per kilowatt-hour for every dollar advance in the price of coal over $3.50 per ton, delivered, and a decrease in the rate per kilowatt-hour when the price of coal falls below $3 per ton, the increase or decrease to be fixed by the average price as ascertained from the company's books on June 30 and Dec. 31 of each year. There will be no advance in rates to lighting customers. The company's big power consumers have been voluntarily paying for several months the advance now proposed to be made general. Although some of them had long-time contracts with the company at cheaper rates, they admitted the justice of an advance.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Dec. 7, 1917	One Year Ago	Dec. 7, 1917	One Year Ago
Buckwheat	$4.98—5.20	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.40—4.65	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	3.90—4.15	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Dec. 7, 1917	One Year Ago	Dec. 7, 1917	One Year Ago
Clearfields	.....	$3.00	.....	$4.25—5.00
Cambrias and Somersets	.....	3.10—3.85	.....	4.60—5.40

Note—Bituminous not on market.

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago; on cars Boston price is $8.50—8.75.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Dec. 7, 1917	One Year Ago	Dec. 7, 1917	One Year Ago
Buckwheat	$3.95—4.65	$2.75	$5.10—5.30	$4.25—4.50
Rice	3.40—3.60	2.20	3.80—4.10	2.50—2.75
Barley	2.90—3.15	1.95	3.00—3.30	2.20—2.60

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate)	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Dec. 7, 1917	One Year Ago	Dec. 7, 1917	One Year Ago
Buckwheat	$2.90	$2.00	$3.80	$2.90
Rice	2.40	1.25	3.40	2.15
Boiler	2.20	1.10	3.30	2.00
Barley	1.90	1.00	2.15	1.90

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Dec. 7, 1917	One Year Ago
Slack	$3.00—3.25	$4.00—4.50
Mine-run	3.00—3.25	5.00
¾-in.	3.50—3.75	.....

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Counties Williamson and Franklin	Harrisburg Saline and	Smokeless field West Virginia	Spring-	Counties Clinton and Sullivan
Steam lump	$2.65	$2.65	$2.70	$2.65	$2.65
Lump	2.65	2.65	2.70	2.65	2.65
Egg	2.65	2.65	2.70	2.65	2.65
Nut	2.65	2.65	2.70	2.65	2.65
No. 1 nut	2.65	2.65	2.70	2.65	2.65
No. 2 nut	2.65	2.65	2.70	2.65	2.65
No. 3 nut	2.65	2.65	2.70	2.65	2.65
No. 1 washed	2.65	2.65	2.70	2.65	2.65
No. 2 washed	2.65	2.65	2.70	2.65	2.65
Mine-run	2.40	2.40	2.40	2.40	2.40
Screenings	2.15	2.15	2.20	2.15	2.15

Hocking lump, $2.60; splint lump, $2.40.

Northern Illinois thin vein—Prepared sizes, $2.65; mine-run, $2.40; screenings, $2.15.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Dec. 7, 1917	One Year Ago	Dec. 7, 1917	One Year Ago	Dec. 7, 1917	One Year Ago
6-in. lump	$2.65	$3.00	$2.65*	$3.00	$2.65	$3.00
3-in. lump	2.65	3.00	2.65*	3.00	2.65	3.00
Steam egg	2.65	3.00	2.65*	3.00	2.65	3.00
Mine-run	2.40	3.00	2.40*	3.00	2.40	3.00
No. 1 nut	2.65	3.00	2.65*	3.00	2.65	3.00
2-in. screen	2.15	3.00	2.15*	3.00	2.15	3.00
No. 5 washed	2.15	2.75	2.15*	2.75	2.15	2.75

*Strike.

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona	2.15	2.40	1.90
Black Creek, Cahaba	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Columbia—The Houston Power Co., recently organized, plans to build a hydroelectric plant here. H. F. Deal, Pres.

Ala., Mobile—Chickasaw Shipbuilding Co. plans to erect an electric-lighting and railway system for the employees of the plant. J. F. Coleman, Gen. Supt.

Ala., Tuscaloosa—The Tuscaloosa Railway and Utilities Co. plans to build a new power station. I. W. Ross, Gen. Mgr.

Calif., Fresno—The San Joaquin Light and Power Corporation has secured rights and sites on Kings River and plans to build a new series of plants. E. A. Quinn, Gen. Supt.

D. C., Wash.—The Potomac Electric Power Co., 14th and C Sts., N.W., is having plans prepared by Milburn, Heister & Co., Arch., Union Savings Bank Bldg., for an addition to its plant. Estimated cost, $27,000. Noted Sept. 4.

Ill., Chicago—O. C. Huffman, 5730 West 12th St., plans to build a 1-story, brick boiler house. Estimated cost, $10,000. S. N. Crowen, 30 North La Salle St., Arch.

Mich., Port Huron—The Mueller Manufacturing Co., River Rd., Sarnia, Ont., is having plans prepared by James, Loudon & Hertzberg, Arch., Toronto, for a 60 x 100-ft. power house, to be built here.

N. J., Burlington—City has had plans prepared for the erection of a new power plant. Haines & Sherman, 415 Market St., Camden, Engrs.

N. J., Haddonfield—The Boro. Council plans to build a municipal electric-lighting plant on a site on Evans Pond.

N. J., Newark—The United Color and Pigment Co., Evergreen Ave. and Pennsylvania R.R., is having plans prepared for a 1-story power house. Estimated cost, $10,500. P. B. Taylor, Essex Bldg., Engr. Noted Nov. 20.

N. J., Red Bank—The Roberts Safety Water Tube Boiler Co. is having plans prepared by the H. D. Best Co., Arch., 52 Vanderbilt Ave., New York City, for an addition to its power house.

N. J., Riverton—The Riverton & Palmyra Water Co., Morgan and Bank Ave., has been granted permission by the Bd. of Public Utility Comrs. to issue $25,000 worth of stocks to improve and build additions to its plant and system.

N. Y., Buffalo—Cousins & Son Boiler Works, 74 Wabash Ave., plans to build a 80 x 120-ft. boiler shop at Hamburgh Turnpike, Childs St. and Buffalo Creek R.R.

N. Y., Buffalo—Farrar & Trefts, 67 Perry St., has had plans prepared by the Ferguson Steel & Iron Co., Arch., 1399 Bailey St., for a 1-story power house.

N. Y., Hornell—Village has applied to Public Service Commission for permission to build a large electric light plant to supply the community with electric light and power.

N. Y., Jordan—The Jordan Electric Light & Power Co. plans to improve and build an addition to its power system. E. S. Mann, Supt.

N. Y., Lockport—Niagara County plans to erect an electric-lighting plant on the Old Almshouse site. F. H. Krull, Co. Clk.

N. Y., New York—(Borough of Queens)—The Astoria Heat, Light & Power Co., 124 East 15th St., plans to build a grinding mill at the East River and Casin Beach. Estimated cost, $25,000.

N. Y., Utica—The Bossert Corporation, 1021 Hickory St., is having plans prepared for a 20 x 80-ft. boiler house. Frank Norman, Pres.

N. Y., Watertown—City is having preliminary plans prepared by S. M. Green Co., Archts., 293 Bridge St., Springfield, Mass., for a new power plant. Estimated cost, $300,000. J. W. Knowlton, Pres. of Water Board.

Ohio, Toledo—The Northwestern Ohio Railway and Power Co. plans to build a new transmission line from Danbury Stop to Danbury, 1½ mi. to supply the large pumping station of the New York Central R.R. with power. The company will also install additional transformers at its station. E. A. Burrill, Toledo, Gen. Mgr.

Penn., Coatesville—Chester Valley Electric Co. plans to issue $45,000 bonds to extend and improve its plant. F. W. Harris, Supt.

Va., Martinsville—B. F. and R. P. Gravely plan to rebuild the boiler room and shed at the insulator pin factory which was recently destroyed by fire.

Wis., Appleton—The Trustees of the Lawrence College plans to purchase 2 or 3 large boilers for the college heating system.

Wis., Glidden—The Northern Wood Products Co. plans to build an addition to its power plant and hardwood factory. Estimated cost, $40,000. W. A. Thomas, Pres. and Gen. Mgr.

Wis., Superior—The Globe Shipbuilding Co., 1713 Broadway, plans to install 3 electrically operated traveling cranes.

Alta., Gwynne—A. Rasmusson plans to install an electric-lighting system here.

Ont., Omemee—City plans to install a hydro-electric power plant. Estimated cost, $9000. W. H. Kennedy, Clk.

Ont., Parkhill—The town plans to build a hydro-electric power plant. Estimated cost, $12,000.